Systems Analysis and Data Processing

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Preface

Present day management is growing more and more complex as the business environment is being rapidly changed by technological developments. Today, technology is considered to be one of the major resources of an organisation. The term 'technology' was formerly applied mainly to the area of production and related to manufacturing techniques. However, with the phenomenal growth of Management Science, the term was extended to other areas of business activity like Marketing Management, Personnel Management, Transportation Management, etc. With the gradual development of quantitative techniques, it was increasingly realised that given better data analysis, the quality of business decisions would improve. As wrong decisions began to prove increasingly expensive, the taking of the right decisions at the right time assumed vital importance. This meant that all relevant data that led to a decision had to be analysed more critically and quickly. The development in data processing and data communication technology provided the answer to this problem. Businessmen were the first to realise the potentialities of this knowledge and they began to apply this new technology to their business activities.

In the highly industrialised nations, the present decade is aptly described as the computer age. The computer has not only aided better decision making but has made business

operations more efficient The advantages of a computer are so widely recognised end applied that it has become a hallmark of man's progress

In India, the computer is yet to get a firm foothold in our national life though positive beginnings have been made in that direction We have in India a few hundred computers though most of them are obsolete by Western standards There is, however, an ewareness both at the Government and the business management levels thet a computer is something which we cannot do without if our progress is to be rapid

A computer is only a tool to serve e menager In order to use this tool effectively every manager needs to know the fundamentals of data processing It is essential for him to heve a basic idea of what a computer does and is cepable of doing in terms of processing data required by him for efficient decision making planning and control He must also know whet must take place before a computer cen process information and meet his needs satisfactorily This is the systems analysis and programming phese It will be a truism to sey that without this knowledge e modern manager's education is not complete

Systems analysis techniques form a major part of the data processing technology In fact, it could be called its brain It is the Systems Analyst who formulates the system and specifies the role of the computer The computer is only a tool and like all tools, it is the competence and skill of the user that determines its efficiency In the final analysis, it is the Systems Analyst who determines what data should be processed and how, when end where Systems Analysis has, therefore, come to have a pride of place in the science of data processing The first part of this book deals with this aspect

A Systems Analyst, if he is to perform competently, must have a good idea of the computer and how exactly the machine processes data in accordance with Management's needs The second part of the book deals with this aspect

The importance of including systems analysis and data processing as an integral part of the study of the Management Science has been realised not only by the Universities and premier Institutes of Management, but also by professional bodies like the Institute of Chartered Accountants of India. In fact, this subject is being included, and rightly so, in the curriculum of many university courses. Students appearing for these examinations will find this book meeting their requirements adequately. The contents of this book have been drawn up primarily to meet the need of such students.

This book is also intended to provide working managers a basic appreciation of the subject of systems analysis, and data processing. It need not be emphasised that the computer is slowly coming into its own in India, as has already happened in the developed countries. The emphasis in the book is on the essential concepts that underlie the use of computers and on the application of these concepts to the business enterprise. It is widely recognised in Government, business and industry that human obsolescence is a very major problem in the modern era. A manager has literally to run to keep himself stationary, because knowledge is advancing rapidly. Managers who do not want to become obsolete in terms of knowledge, will find in this book a good aid.

In India, it is usual to see Systems Analysts being recruited from among young men working in other disciplines in the same company. The training of these personnel in systems analysis has often posed problems due to a lack of training material and training personnel in this area. It is expected that this book will prove useful for such personnel. The reader, especially one who is new to the subject, might face one difficulty in understanding some of the terms especially when they are used for the first time in the book. For example, many terms relating to the computer and which have been defined or explained in greater detail in Part II (Data Processing) have been used in Part I (Systems Analysis). A glossary of all important terms used in the book is given on page 219 and it will help the reader to look up this glossary whenever he stumbles upon a new term whose meaning is not clear.

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Part One
SYSTEMS ANALYSIS

1. Systems Analysis—An Introduction

Systems analysis can be viewed as the most recent and perhaps the most comprehensive technique for solving complex problems. It has evolved from a long history of problem analysis using the heuristic technique (learn and relearn). it borrows as much from the scientific era as from the ancient Persians, Greeks and Indians. It is not completely new or different. In fact, it is not unique. Its power resides in the way its method synthesises the approach of history's great experiments.

In the developed countries the military, business and industry, and to a lesser extent Government institutions, have been the ones who have made the most use of systems analysis. In India, it has been catching up only slowly, mainly for lack of adequate know-how.

Systems analysis may be considered as an interphase between the actual problem and the computer—a kind of midwife to all computer applications. Before a computer can perform, it is necessary to investigate and analyse the system. The individuals who perform the systems investigations, as distinct from those involved in the detailed computer programming, are called Systems Analysts.

As in the case of all other techniques, Systems Analysis does not guarantee that the user will derive an ideal solution to a problem. This depends solely on the way one designs a system to exploit the potential in the method. To put it in another way, creativity is as much a requirement as knowledge of the technique itself. Most of us unfortunately tend

to become too lazy to use our creative talents which the good Lord has bestowed on us in ample abundance To cite an example most people who usa a computer produce data processing systems which are just automated copies of tha original manual systems These well meaning experts have just failed to exploit tha tool of the computer in a creative way Change does not descend from the Heavens as a gift it originates In tha minds of men It was once thought that a creative person was ona of those rare species of humanity This has been proved to ba totally wrong Cre ativity is a science and can be learnt It is termed a science because its approach is scientific

Systems analysis therefore is not e magical formula or an equation where inputs introduced in a certain way will provide an output that fully meets one s needs One must pre dasign tha study end the problem solving process end evaluate every successive step in the systeme analysis One must realise understand and define objactives and similarly realise understand and define one s constraints One must creatively think out and identify elternatives end be in e position to evaluate them in terms of effect venass efficiency end economy three factors which form the core of Manege ment

Systems a Definition

The word System covers a very broad spectrum of concepts We talk of the solar system the body s nervous system a mountain or river system the transportation sys tem the communication system the computer system the economic system and myriads of other systems There are various definitions of a system some of which are given below

1 A system Is an array of components designed to achieve an objective according to plen

2 A system is an organised or complex whole en essemblage or combination of things or parts forming a com plex or unitary whole

3 A system is an aggregation or assemblage of objects by some form of reguler interaction or inter depen dence a group of diverse units so combined by nature or art

as to form an integrated whole, function, operate or move in unison, and often, in obedience to some form of control; an organic or organised whole; as to view the universe as a system, the solar system, the telegraph system. (Webster's New International Dictionary).

In the above definitions we see

(i) A purpose or an *objective* which the system is designed to perform;

(ii) A "whole", which we call the system;

(iii) A large number of variable elements, which form the whole. These may be men, materials, machines, information, energy, etc.;

(iv) An inter-relatedness between the elements, or a design, or an established arrangement of the components.

To understand this a little better, let us take "Management" in a complex business enterprise. The main task of Management here would be to coordinate the myriad activities of the various operational units and optimise the total efficiency of the enterprise as a whole. It would be the task of a Manager to understand the business, not in terms of isolated parts, but as a total system. In other words, he must possess a sound knowledge of the inter-relationship between the various parts and be aware of their potential interactions and view the whole system in an integrated manner.

It is not usually realised that a very simple decision taken by a Manager, which he considers to be in the best interests of the company, can have major repercussions elsewhere. To illustrate : Mr. A is a Marketing Manager who feels strongly that the best way of motivating the sales force is to give them targets which are twenty per cent higher than what he thinks is achievable. His philosophy is : "Aim at the sky and you will reach the top of a tree". The Production Manager builds up his annual production programme on this higher target. He, in fact, is not aware of the extra padding. The Materials Manager enters into annual contracts for the raw materials on the basis of the production requirements. At the end of the year we find twenty per cent higher inventories of either the raw materials or of finished goods with all its consequent financial repercussions, and naturally a dec-

rease in profits arising from unnecessarily locked-up capital higher inventory carrying costs, etc If only Mr A had realised that the Sales Department is not an isolated unit but is a part of a system with strong inter-relationships with Production Finance Materials and Personnel Departments, his company would have fared better The Management of a business enterprise can solve many of its problems and improve its operational efficiency by adopting a systems concept and managing the enterprise as a system

Systems Study and Systems Analysis

It would be necessary for us to understand the difference between systems study and systems analysis We may define the study of systems as 'a study of the operations of a set of connected elements, and of the inter-connections between these elements" What it implies is that one cannot ignore any part or element of a system without first finding out the effect that element has on the operation of the system as a whole What helps us to understand this is systems analysis The one main advantage of business systems is that they are goal oriented, i e , they have objectives and a defined set of results to be achieved As a sequel each element or sub-system has an objective and since we can identify this objective the direction of our thinking gets into sharp focus For example a financial system will have several sub systems, e g payroll budgetary control, cash flow etc The system and its sub systems are expected to achieve their objectives in an optimum manner

There is a difference between 'systems approach" and systems analysis" The former term denotes a specific strategy or set of methods for tackling a particular problem It involves the application of a scientific method to observe clarify identify and solve a problem with special care being taken to understand the inter-relatedness between parts and their system characteristics However systems analysis is a management technique used in designing a new system, improving an existing system or solving a system problem Systems Analysis and design constitutes the major planning element in the preparation and installation of a data processing system One of the key assumptions in systems ana

lysis is that the needs of a manager can to a great extent be met by the development of a durable system in which outputs, or information processed by a computer, and inputs, or data fed into a computer for processing, are regularised.

Systems analysis covers a large number of disciplines and has possible applications for research in mathematics, physics, statistics, engineering, physiology, cybernetics and a host of other sciences.

Most systems are complex in nature and have a large number of variables. Further, there are what one might call wheels within wheels—an overall system and many subsystems within it. Because of this fact, the concept of total or integrated systems approach has developed in management thinking, especially in regard to Management Information Systems. With the advent of the computer, such an integrated approach has become possible and what is more can be achieved in a remarkably efficient way even in the most complex system. For example, in a production enterprise, it has been possible to analyse and integrate various subsystems like purchasing, storage, inventories, material requirements planning, production planning, production control, fabrication, assembly, transportation, etc.

Elements of Systems Analysis

The conventional method of analysis is through techniques of "Organisation and Methods". This is primarily aimed at work simplification in a department or section. The one drawback here is that we do not take into consideration whether the department is doing what it should actually be doing. The systems approach is broader in scope and the Systems Analyst does not adopt this rather conventional technique of analysis.

There are four elements in systems analysis:

(i) Outputs (Results),
(ii) Inputs (Data),
(iii) Files, and
(iv) Processes (Programmes).

These are described below:

(i) **Outputs:** We must first determine what the objectives or goals are, what are we after, what is the purpose

of our work, what do we intend to achieve, what information do we want, in other words, what is the purpose of the system Defining objectives is very vital in systems work If we do not know where we want to go, we will not know when we have reached there We will be wandering aimlessly and spending quite a lot of energy, time and money unnecessarily in the process Once we know our objectives we can work backwards and see how we can best achieve this objective The user department has to define these objectives in terms of their needs These become the outputs which the Systems Analyst takes into consideration

One matter of vital importance that we must remember is that quite often we are engaged in structuring something new If we concentrate on what exists now i e, the present outputs and the present objectives or goals of the existing system (may be a manual system), we can be completely misled into believing that the present outputs are what we are after The best advice is to ignore the present outputs and start off the investigations and analysis by conceptualising what should be We can often be carried away by what exists now and it is very vital for a Systems Analyst to be extremely careful in not making this mistake

(ii) Inputs Once we know the output we can determine fairly easily what the inputs should be Quite often it may happen that the information is not readily available or not available in the form in which it is required This is because the existing forms are not designed to provide this information It may not often be easy to get the information in the form required, unless authority is exercised by someone higher up sometimes, may be even by the Top Management If the information is vital to the system, then no effort should be spared to make it available The system being designed must provide for this information to be generated Sometimes it might be too costly to obtain the information It would, therefore, be necessary in such cases to prepare a cost benefit analysis to convince the Management of the necessity for obtaining the information

The essential elements of inputs are

(a) Accuracy If the data is not accurate, the outputs will be inaccurate

(b) Timelines. This is of the essence. If data is not obtained in time, the entire system falls into arrears.

(c) The inputs must be available in the form required.

(d) Economy. The data must be produced at the least cost.

Another point worth mentioning is that we should be careful not to be misguided by the present inputs. Some of them may be irrelevant, or may involve too much cost (in terms of manual work), and which is quite disproportionate to the benefits, or there may be significant omissions and so on. If the present system has an input, it does not automatically follow that it is needed for the new system also.

(iii) **Files** : As the word implies, files store data. Most of the inputs necessary for the system may be historical data, or it may be, that these are generated from within the system. These are recorded in files either in terms of isolated facts or in large volumes. We shall be dealing with this subject in greater detail in Chapter 5.

(iv) **Processes** : Here we come to the details of how the inputs and files are converted into outputs. This involves the programmes and the manner in which data is processed through the computer. The processing involves a set of logical steps. These steps are required to be instructed to the computer and this is done by a series of "instructions" called "programmes".

2. *Basic Steps in Systems Analysis*

In any kind of modern Management technique one will notice what is broadly termed as a Scientific Method In Systems Analysis also, it is necessary to follow a Method Different authors hava specified different methods This is unimportant What is important is that the Method itself is logical rational, sound, valid and relevant The analysis can ba divided into six broad phases —

(i) Selection and identification of the problem or project to ba studied

(ii) Making a cost-benefit analysis and conducting a feasibility study of the project

(iii) Dafining precisely what the problem is

(iv) Dasigning tha system

(v) Implementing the system including updating and maintaining tha system

(vi) Evaluation of the working efficiency of the system

These six steps are described below

STEP I Selection

There are several ways in which a particular project comes to be chosen

(i) The most usual reason for selection of a project is an organisational requirement

(ii) Often requests come from Departmental Heads within the company For exampla, the Finance Manager feels that he should have a detailed breakup of costs on a monthly basis, or the Marketing Manager feels that it would be a good idea to obtain product-wise, areewise, salesman-wise, sales

and profitability. Though by themselves these requests are justified, one would perhaps like to think of the effect that a new system would entail on the whole organization. It might mean perhaps a company-wide restructuring of codes to generate this information. The cost and benefits would then have to be compared and may be the ultimate decision might be to modify the request and adjust it to suit the present availability of information.

(iii) The necessity to integrate or link other systems, might lead to a selection of a new project. Let us say we are formulating a system for Inventory Management. We find that the system has a great co-relationship with the system of production scheduling which in turn has a relationship with the sales forecasting system and so on. To attempt to structure an inventory control system in isolation would be a futile task.

(iv) Similarly, when we have completed a systems study, we may find considerable potential in another area which would be worth an investigation.

(v) Very often we get ideas from outside sources—may be a similar we attend or some article in a professional journal or newspaper. A success story, perhaps, of having effected considerable savings as a result of systems improvement, might give us encouragement to carry out a project study because one finds near identical conditions in one's own company.

There could perhaps be several other reasons or ways and means as to how a project comes to be selected. Perhaps a new Government regulation necessitates a review of an existing system or perhaps the Board of Directors or the Top Management have suggested a study of a particular area, or may be, Audit has found some loopholes in a system and have suggested its streamlining, a recommendation which Management has accepted, and so on. However, some broad criteria should be evolved for project selection. Some of these are:

(i) A cost-benefit analysis will reveal how much benefit one can obtain from the study. If the benefit is not commensurate with the labour, time and expenditure involved, it is best to shelve the project to a period when you have

nothing better to do Priority of studies should be based on their benefits These benefits might be physical, like speedier movement, or financial like cost reduction or abstract, like better customer satisfaction

(ii) As stated earlier, the Board or Top Management may have wanted to make a study It is not unusual to see the subject getting top priority By making a good job of it, by bestowing extra attention one can get the goodwill and support of Top Management

(iii) One question that needs to be asked is 'Do we have the capability of doing the job? In many cases the technical know how may just not be available with the Systems Department There are for example many projects which involve a very complex use of the computer and if one takes up one such project without adequate care then one could end up in disastrous failure much to the amusement of others Maybe a solution is hiring outside consultants but then this increases costs

Capability within the company therefore is a crucial criterion for project selection

(iv) We had talked of integrated systems earlier This would be an important criterion since the particular system under study cannot be completed without a parallel study of related systems

(v) Finally, there might be a critical corporate need for a specific information to be generated The project might easily get rejected by cost benefit evaluation but such considerations become of secondary importance The benefits in this case may be abstract and difficult to define

After we have selected the project and defined it precisely and clearly, we proceed to Step II, where we do a cost-benefit analysis and feasibility study

STEP II Cost-benefit analysis and feasibility study

Cost benefit analysis has three portions (1) Costs, (2) Benefits (tangible and sometimes intangible), and (3) Return on investment

1 Costs would include

(i) Cost of the Systems personnel and the user Depart-

ment personnel who will be assisting in the study, plus all the overheads involved, and the cost of generating the inputs.

(ii) Machine costs including cost of computer time, storage equipment, or new equipment if the study suggests it, etc.

(iii) Other costs, e.g., power, air-conditioning, space, etc., which might become necessary.

These costs are not one-time costs. They are spread out over time from the study phase to the implementation and operating phase. One has, therefore, to think of cumulative costs as well as cumulative benefits.

2. Benefits will include :

(i) Direct savings like reduction of clerical payroll costs, elimination of certain costs on stationery, office machines, space, etc., and finally reduction in costs due to the improvement in the procedures, e.g., eliminating the requirement of checking figures.

(ii) Tangible benefits which are measurable. For example, quicker billing can result in quicker collection or quicker follow up. Similarly, quicker inventory status reports can lead to stricter control and result in lesser inventories with substantial financial benefits.

(iii) Intangible benefits can also be expressed in equivalent cash gains. Take for example, a cash flow statement prepared at the end of each day. There are several benefits which the company can gain as a result, e.g., improvement in funds utilisation according to optimum return, follow up on outstandings, better satisfaction to suppliers, quicker decision making etc. All these, though classified under intangible benefits, do result in gains which can be quantified.

3. **Return on Investment**

When the cost-benefit analysis has been completed, it is possible to decide whether a project is worthwhile for the company to undertake. There can be two criteria to decide whether it is worthwhile—one is purely financial and this can be measured in terms of return on investment; and the other might be purely non-financial, which would be a subjective proposition.

The financial consideration is the most important of the two The period of time between the operation of the new system and the point of time by which the entire investment is recovered through the benefits is called the payback period In some cases the investment might be large and obtained from borrowed funds The return might spread to five or six years and in an inflation bound economy the real value of the return might diminish as years go by while interest accrues on borrowings These factors have to be taken into consideration The Discounted Cash Flow method (DCF) can be used for such calculations

However in many cases profitability or return on investment may by itself not be the sole criterion on which it is decided to install a system There might be other reasons for example to be progressive and the hope that such e system will have benefits during the future growth of the company However these non financial or intengible considerations are matters on which tha Top Managsmsnt may teke dacisions Tha Systams Department is concerned mainly with the financial aspacts The Feasibility Study should therefora claarly show if tha system will meet the objectives and if so at what cost and at what return on investment

To summarise—

(i) Tha important characteristics of the system should be identified

(ii) The inputs and outputs and the important resource of time should be determined

(iii) The numerous varieties and volume of information to be generated and the data from which such information is to be generated should be determined

(iv) Find out if there are alternative ways of giving the user what he wants Find out what other systems meet the requirements of a similar nature with a view to examine common areas common approaches etc

(v) Calculate estimates of costs for each alternative Similarly calculate financial benefits (both of tangible and intangible benefits) of each alternative

(vi) Make out a Feasibility Report from the above data to enable Management to take a decision Present in the

report all the relevant information and also indicate the intangible benefits which cannot be quantified in financial terms.

STEP III. Defining the system

Once the feasibility study indicates that it is worthwhile to have the system we go to the third phase of defining the system and examining each and every element and part of it in a thorough manner. One of the fundamental pre-requisites for this is a great fund of teamwork between the Systems Department and the User Department and an open, frank, intelligent approach to analyse problems. Defining the problem is not often an easy business. What appears on the surface might only be a symptom. The problem might be altogether something else. The analyst must, therefore, record all the facts available asking the six famous questions:

1. WHAT? (What is being achieved? What is the process?)
2. WHY? (Why is it necessary?)
3. HOW? (How is it done?)
4. WHERE? (Where is the work done?)
5. WHO? (Who does it?)
6. WHEN? (When is it being done?)

He must probe into the problem in depth instead of being merely satisfied with the superficial facts of the problem. If this is not done there is the danger of missing the wood for the trees.

As in any management situation, it is best to start by defining objectives—here, the objectives of the system, i.e., what are the various goals which the system seeks to achieve? There will be the main objectives of the system and the sub-objectives of the sub-systems.

A danger to be guarded against deserves a word of caution. The objectives should not be defined in abstract or vague terms. For example, do not state objectives like : "to increase customer service" or "reduce finished goods inventories", or "improve cash flow" and so on. A pertinent question is how much to increase or decrease. The objective then should be expressed in measurable terms, e.g., reduce delivery times of Product X, Y, Z by 25% send

customer bills in 48 hours produce inventory data by the 5th of each month reduce inventories by 15%, etc

The sub system objectives must be consistent with the main system objectives and also with the overall goals of the Information System There is also no purpose in laying down objectives which can be achieved only on paper They should be down to earth and practicable

Take the following for example

Main Objectives	Sub Objectives
To reduce inventories by 15%	1 Reduce inventories of all A category items by 30% B items by 12% and C items by 10% 2 Weekly report on all outstanding orders and status of overdue shipments beyond 2 days 3 Weekly report of Production Schedules and exception reports of raw material and components availability

The Systems Analyst should define the problem in this manner on a step by-step basis starting from the main objective to the sub objectives and filling in as many details as are necessary to understand the problem fully Once an objective is defined it is possible to list out all the data elements required to get the necessary output from the system (A data element is the lowest level logical unit of information The name of a customer the unit rate the distributor's code and the mode of transport are all data elements)

Once we know the data elements we can then find out how they can be introduced into the system To start with we will notice that there are relationships between elements e g material code unit rate price excise sales tax etc In the next step—the design of the system—we will see how these inter relationships help in file organisation

In the manner stated above, we obtain a definition of *input output and file* content of the system

To summarise—

1 The objectives and sub objectives of the system should be defined

2 Alongside we should also be aware of the constraints on the system and we should identify and define them

STEP IV. Designing the System

We now get on to the job of designing the system. The various elements of the system would include—

* Flow of information
* Data files
* Designs of printouts
* Methods and procedures
* Forms
* Specifications of the programme, etc.

The broad pattern of information flow would have been established when we identified and defined the system in Step III. When we design the system, this would be defined in as great detail as necessary. Once we have defined the information flow, we can make a Master Chart of the system showing—

* the inputs
* files
* processing stages
* error recycling
* outputs

One of the factors to be noted is time, i.e., the periodicity of reports, the retention period of files, etc.

Two useful tools in designing a system are—

* Decision tables and
* Flowcharting.

These are described in detail in Chapter 3.

An important methodology to be followed is to divide a system into elements. In any method analysis, this technique is followed. The logic is that it is far easier to handle an element or a sub-division of a problem than the problem as a whole. This is also called the modular approach. The advantages of such an approach are—

(i) The entire problem can be divided in terms of complexity and in terms of human skills required to undertake the tasks. This makes for better human resource utilisation.

(ii) It makes for easier documentation because we are dealing with one specific subject at a time.

(iii) It becomes easier when any modification is called for.

(iv) When we examine each element or module it enables a thorough understanding of the subject as a whole This also helps in analysis

(v) One of the main advantages with a modular system is in regard to integration with other systems

(vi) The designing of modular systems is comparatively easy

(vii) A general purpose module can be tailored to suit a number of different purposes within a given range For example take a file containing the following elements of data

(a) Customer name code number and address
(b) Type of customer
(c) Sales area
(d) Divisional Office
(a) Unit rate and discounts
(f) Total purchases made this year

The information contained in this file would be used by the Sales Officer Divisional Office Sales Accounting Customer Ledger Section Statistics etc Such a system is also called a parameter approach It is a generalised programme which will print out all permutations or combinations of elements of data from a given file

The task of designing a system calls for a great amount of innovation and creativity to get the maximum advantage One of the main aspects which should be borne in mind is that the design should be flexible for the user This means that the Analyst should not have to be bothered about designing a special retrieval run out every time such a need arises The emphasis here is on creativity A very simple definition of creativity is that it is the process of combining already existing elements into something that is new in so far as the creator is concerned for the purpose of solving problems Creativity is just a matter of thinking in new ways as opposed to following the beaten track

To enable an Analyst to design a good system the following may be done

(i) Other systems which are used in similar situations should be examined in detail to find out if useful ideas can be borrowed It is very rarely that we get a problem which is

altogether unique. Similar problems always exist and if one can benefit by the experience of others, such an opportunity should never be missed. There is an old saying that if I have a rupee and you have one, and we exchange our rupees, each of us is left with one rupee. However, if we have an idea each and exchanged them, each of us would be left with two ideas. One of the permanent preoccupations of an analyst should be to generate and exchange ideas.

Similarly, ideas can be obtained from printed literature. This is one source which an analyst should make use of in abundant measure. He should cultivate the habit of reading and keeping a handy reference index for himself.

(ii) Brainstorming is a very potent technique for idea creation or ideation. Here, a group of people conversant with the related problems sit around a table and generate ideas—one person after the other; one idea after another on a specific, well-defined problem. There should be no criticism of the ideas generated and it is usually said, the wilder the ideas, the better. Ultimately, in a 45 minute session, some ten people might have generated 150 ideas. Most often, 95% of the ideas turn out to be unworkable. 5% turn out to be feasible and after evaluation, one would probably get five ideas which are really good. But the effort and time spent on getting those five ideas are comparatively negligible to the value of these five selected ideas.

(iii) Various available techniques should be used, e.g. decision tables, statistical techniques, simulation, etc.

(iv) Enough time should be devoted to the Design Phase. It usually takes upto 25% of total time.

The end product of the Design Phase will be a document having the following:—

(i) Narration of the functions of the system.

(ii) A Procedure flow chart indicating the major manual and computer operations of the system.

(iii) The inter-relationships between inputs, outputs, and files.

(iv) The linkages between programmes.

(v) Flow charts giving in detail the interaction of input, output and files.

(vi) The specifications of the programme.

(vii) The specifications of the files

In addition one may have to prepare a revised estimate of the costs of the programme as the details would have become clearer now than in the earlier step

To summarise—

(i) The following should be finalised

* Information flow
* Elements of the data required
* Outputs
* The relationships between data

(ii) The following should be identified

* Master files
* Working files
* Data volumes
* Frequency of updating
* Ratention period
* Response times required from files

(iii) The file organisation and layouts should be determined

(iv) The layout of inputs frequency etc should be specified

(v) Reporting requirements volumes frequency distribution etc should be defined

(vi) The overall logic of the system should be developed

(vii) The controls and procedures for audit should be defined

(viii) Manual procedures and the computer programmes should be identified

(ix) The programme specifications should be prepared

(x) The general test requirements should be prepared e g type of data source control checks etc

(xi) The detailed plan of implementation should be prepared

(xii) A report should be prepared for the user and for Management

(xiii) Decide upon the storage devices that will be used

Based on the specifications the programmer writes the programmes and validates them Meanwhile the Systems Analyst develops the test data with the help of the user

department. The system is then tested first with the test data and later with the actual (*live*) data in Step V.

STEP V. Implementing the new system

When we have designed a system, it is essential that we implement it and obtain a fully operational system which satisfies the intended objectives. The Implementation phase is the point at which many well designed systems get derailed. Hence the need for giving it considerable importance and attention. Many of the new systems—

* do not even get implemented for some reason or the other;
* are implemented without adequate attention being paid to introduce proper control with the result that master files become unreliable;
* get implemented while there are many errors in the programmes, and, therefore, lose their credibiity; and
* are implemented with the users not adequately trained to use the system resulting in confusion and a feeling that the system is unreliable.

If any of these things happen, then everything is lost, because the user's confidence gets lost and he becomes biased. Even if the bugs are removed later, it becomes an uphill task to get the user to fully cooperate.

The Systems Analyst has, therefore, an important role in regard to the implementation of the system.

The procedure that should be followed is as follows:—

(1) It is necessary to plan the entire system fully and exercise strict control to ensure that performance is according to plan. One of the most important facts to remember in systems work is that considerable changes will take place. As one progresses with the implementation, one may find all kinds of unexpected problems cropping up, and, therefore, a flexible planning and control system should be applied. Rigidity can create confusion and a resultant poor performance. Do not be afraid to change a plan. It is not an indication of bad planning. It would be advisable not to forget that when we plan we are making certain logical estimates in regard to uncertain future possibilities. If our premises prove different from what we had presumed, there is no pur-

pose in continuing with our original plans In fact it would be foolish to do so

(2) It would be very desirable to assign tasks to each individual who is participating in the systems project and also lay down objectives for each of them Time is an important element in setting up objectives In other words they must know what to do and achieve by such and such time This is a good principle in organisation and is of special importance in systems work

(3) It should be ensured that standards are laid down for all phases of the work The methodology in regard to this is given later

(4) The user and the data processing staff should be well trained in the use of the new system This training includes such matters as—

* Input preparation
* Correcting errors
* Operation of computer
* Scheduling of jobs
* Output interpretation
* Right selection of stationery
* Application of check totals
* Report distribution
* Allocation of time etc

It would be desirable to prepare user and oparating manuals and distribute them well in advance

To summarise—

The main activities of the Implementation phase are—

(i) The computer programmes should be written and they should be compiled and made error free with test data and actual data

(ii) Master files should be prepared from the data collected

(iii) Newly designed forms should be introduced for the User Departments the Computer Centre etc

(iv) Get the stationery of the right type necessary equipment etc

(v) All the people involved in the Computer Centre and the User Department should be made thoroughly conversant with the new system

(vi) Plan operations and institute a control system for input documents and for processing by computer.

(vii) Full supervision should be exercised while the system is operated. Test and ensure that all parts of the system are working satisfactorily and meet objectives in accordance with the original plan.

(viii) Each system module should be separately tested first by test data and later by actual data. Get the system tested as a unit and then get the user and preferably the audit staff to test the system.

(ix) Actively cooperate and work with the User Department till the system has taken firm roots. Apart from its practical value, it is good psychology.

STEP VI. Evaluating the System

Merely getting a new system operating without errors is not the end of an analyst's job. It is desirable to evaluate the system after a period of time—may be two, four or six months later. There are various reasons why such an evaluation is very desirable.

(i) The actual performance is gauged to find out how well it has achieved the objectives originally set forth.

(ii) The manner in which the system is actually operating should be assessed in order to determine its efficiency and examine whether any improvements can be made.

(iii) An evaluation of the actual performance can give an analyst a great amount of knowledge in terms of the strengths and weaknesses of the system, its good and bad points. This information will be useful for future projects.

The various factors that have to be taken into account while doing such an evaluation are the actual cost of operation of the system, the benefits accrued, the timing, the satisfaction derived by the user of the system, the volume of errors and the consequences of such errors and the areas where problems exist. These should be compared with those estimated during the feasibility and design phases of the project. The variances, if any, should be investigated to determine the reasons for such variations. It is only

through the identification of such variations and their analysis that it would be possible to identify the areas where improvement is possible Very often only slight modifications are required to bring about a considerable degree of improvement

The evaluation done and the improvements made should be written down in the form of a formal report for future guidance

Once this initial evaluation is over the system should be subject to review preferably once a year In most companies the external and internal environments keep changing very fast and it may become desirable to modify the system to suit current requirements This is the most important reason for an annual evaluation

Interrelationship between the six steps

It will be seen that the six steps in Systems Analysis are inter dependent and that one step follows the other in a logical sequence This relationship is illustrated in Figure 2 1 It will be noticed that each step provides a check point where one may take a decision whether it is worthwhile continuing with the project

One will also notice that in these six steps, no mention has been made about studying how the existing system works To study the current system would for example be the primary task of an O & M study While there is no doubt that such a study is essential it is important to realise that computer systems have a tremendously wide scope in terms of systems design that it would be inadvisable to spend a large amount of time and energy being carried away by ineffective existing systems There should be a deliberate attempt to break away from the past and think in terms of something altogether new and perhaps one may add altogether revolutionary The approach should be really aggressive Don t for example ask yourself the question How can the present system be improved? Let us not concern ourselves with the requirements of the past Think of today and the future and decide what is the best we want There is no point in converting old procedures into punch

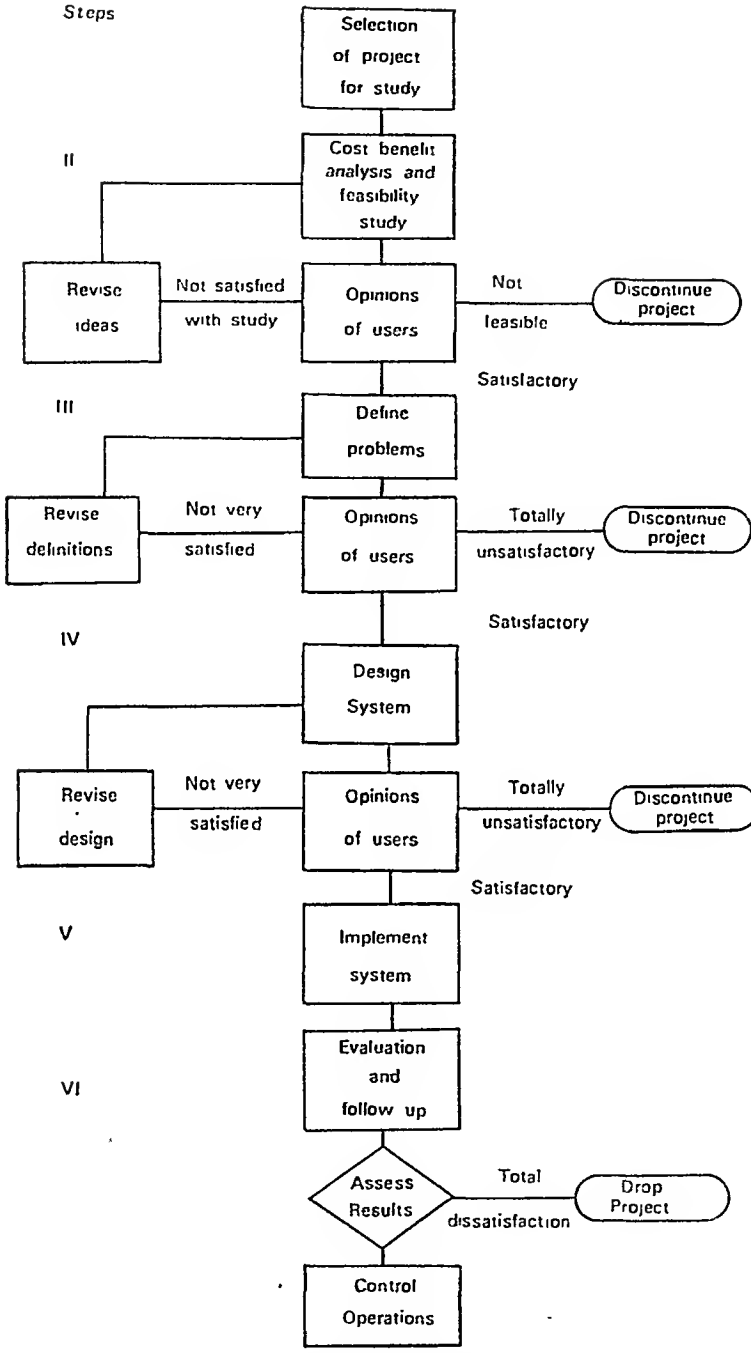


Figure 2.1. Basic steps in Systems Analysis showing their inter-relationships and checkpoints.

cards, then to tapes and so on Discard the old procedures

What has been stated above might not usually find much favour with the conservative traditionalists, who will swear by the past and not want to rock the boat as it were, by taking a risk for the unknown The approach recommended here might even result in a system quite radically different from the old one and even require an organisational change It is for this important reason that it is usually advocated that the Systems Department should be an independent-department and not be part of a functional department, e g Accounts It should be outside the pale of influence of any interested party or vested interest If such an influence is exerted on the Systems Department its efficacy will be diminished to a considerable extent

A check list for the various stages of systems analysis hes been given in Appendix 1

3. Techniques of Systems Analysis

I. FACT GATHERING

One of the main responsibilities of an Analyst is to obtain information about the existing system and about the requirements of the new system. There are various techniques for gathering the information required, but probably the one which is most often used is **interviewing.** Interviewing is an art and has to be cultivated, practised and perfected. To a very great extent, this requires human skills. Some people have a natural aptitude to make themselves acceptable by others, while others have to train *themselves in order to perfect such skills.*

Some of the important factors that contribute to a successful interview are well worth remembering. These are:

1. Put yourself in the man's place and look at the problem the way he looks at it. Cultivate the ability to appreciate his point of view. Understand his frame of reference in regard to the subject he is talking about. Be interested in finding out what he thinks and why he thinks that way.

2. Be sure you really "understand", instead of jumping to conclusions. If something is vague, obtain clarification.

3. Make the person open up. This can be done only if you show a genuine interest in his problems, thoughts and ideas. Let him do most of the talking. Resist the temptation to monopolise the conversation and make the best of

an opportunity to share your ideas experience and suc cesses with him Talk about him not about yourself

4 Listen while he talks Listening is an art If your mind wanders it is usually reflected in your face A person who is speaking hates nothing more than realising that the other person is not l stening Listen attentively

5 Talk of specifics not generalities

6 Do not get emotionally involved Remain calm and unaffected by the position he takes Sometimes he might become angry or be on the defensive

7 Notice what he does not say There is usually as much in what he does not say as in what he says

8 Don t rush the interview and do not pretend you are in a hurry Give him time to think Don t interrupt him as he talks Invite him to express his views or feelings by ssk ing such questions as What is your opinion? What ere the problems you visualise? Do you think that there srs other possibilities? Has anything been overlookad? Avoid leading or loaded questions like Don t you think you should ? Avoid yes/no questions Pay him com pliments where possible This will encourage him to tslk Encourage him to open out

9 Bs prepared for disagreement Never expect that your suggeations will be enthusiastically received however great you may think they are Be careful you do not try hard to get agreement the first time Find out why he does not agree instead of proving he is wrong It is not what you say but what he accepts that will bring him around to your point of view Check the reliability of your own facts and of what he says Be genuinely willing to change your conclusions if the facts justify changing them Never be rigid in your attitudes

10 Distinguish between fact and opinion and between need and desire

11 Finally check the information you have obtained and wherever necessary confirm the results of the discussions

Other fact finding techniques

Besides interviewing there are various fact finding tech n ques which the Analyst can use Some of these are

1. **Official records:** Records usually contain a lot of information relevant to the systems project, ranging from Minutes of Board meetings to the detailed record of accounting transactions. Board Minutes, for example, can reveal exact details of expansion or diversification or matters of policy, etc. What type of documents are to be scrutinised and for what time period, etc. are matters which can be determined only with reference to the context. These will vary from system to system or company to company. Some points to be remembered are—

(i) It should be ensured that the information is accurate and that it relates to a current practice. There is no purpose in searching for information which relates to an obsolete procedure. An example of "accuracy" is as follows: A company with an all-India marketing network compiles provisional figures of sales on a monthly basis and the correct figures are available only after a six month period. Similarly, the procedure for collecting the provisional figures and their source are quite different from the source of the actual figures. The former figures are compiled from warehouse issues while the latter are from Sales Invoices, or cash receipts. One has, therefore, to be sure that the information obtained is the right one. When we design a system, obviously, the warehouse figures are not what we want.

(ii) The information should be cross-checked where possible. We have generally a tendency to assume that what we see in writing is more authentic than what we hear. This is a myth. The fact that a piece of information has been reduced to writing does not guarantee its accuracy. It would, therefore, be very desirable to cross check the information from some other source. For example, a procedure is laid down in a Manual and one believes that it is the procedure actually followed. This need not be so at all. The procedure might have changed but the Manual might not have been updated. It is better to verify and be sure what really is the procedure followed.

(iii) One must find out if the information one is collecting is really relevant or not. Relevancy is an important aspect and is usually taken for granted. To cite the same

example of sales statistics the provisional sales figures and their method of collection might be of little relevance while designing the new system and it would be a waste of time gathering detailed information regarding it

2 Questionnaires Answers to questionnaires are not likely to be as effective as those obtained by interviews In a face to face communication clanfications or explanations can be asked or given supplementary questions can be ask ed and answers obtained and matters of detail can be probed into This is different in a questionnaire which has severe limitations Secondly many people are afraid of committing themselves in writing and often reply in a couple of cnsp two syllable words Thirdly it is difficult to estimate the degree of subjectivity in the replies or assess the validity of the information For all one knows the person filling up the questionnaire might have been in a hurry and might have written the answers in haste without verifying the facts Accuracy may therefore suffer Another drawback in e questionnaire is that unless it is drafted by an expert the question remains vague embiguous or misleading to the reader To cite en example e petroleum company is request ed to furnish its sales figures The doubts are Are ex ports part of sales? Is product exchanged with other oi' companies sales? Is product consumed for one s own use sales? You will notice thet unless these terms are precisely defined a lot of confusion can erise end what the questioner intended may be entirely different from what the replier had interpreted An old truism well worth remembering is to get the right answers one must ask the right questions Drafting a questionnaire therefore requires a high degree of skill and effort

For the above reasons questionnaires are best resorted to only if inevitable For example the survey might be very big and cover all the Divisional Offices of a company located in various parts of the country In such cases a question naire would be advisable but it is better to follow up the questionnaire with a random sample of interviews

3 Random sampling The random sampling tech nique is based on the theory that if we choose a representa tive sample or portion of a population it will have all the

characteristics of the entire population. One can thereby draw firm conclusions of the whole by merely examining say 10% or 15% by a random selection. For example, if we found by random sampling that 10% of the invoices had a value of between Rs. 1,000 and Rs. 1,500, one can infer that almost the same proportion exists in the whole lot of invoices.

This is a statistical technique and is easily learnt. However, care should be taken to ensure that the technique is correctly applied as otherwise one is certain to end up with cockeyed results.

4. **Recording of facts:** The facts should be recorded in as much detail as possible. The use of flow charts is valuable in this regard. This technique is explained later. One of the essential factors in recording is personal observation. Hearsay evidence should be immediately discounted. *Observe things for yourself and be sure of the facts before* you record them. A supervisor might describe to you the way his subordinate actually works, but in reality, the subordinate might have adopted his own methods to suit his convenience. It is best to find out from the subordinate himself.

II. FLOWCHARTING

A flowchart pictorially or diagrammatically traces the flow of information or documents through a specific procedure, process or system.

There are various types of flowcharts. One is the procedure flowchart which charts the procedure from start to finish. Such a chart enables an Analyst to be certain that all the aspects of a system have been covered. While writing his Report, he can use the chart to ensure a clear logical sequence. Such a chart primarily helps one to understand a problem much more than if he were merely to read a long narrative in prose, and this in turn helps one to make a better analysis.

There are three main procedure flowcharting techniques which are commonly used to represent activities and events symbolically. Each method employs its own set of symbols to signify the steps in the procedure. These standards are—

1 The symbols used in Work Study and O & M These are shown in Figure 3 1
2 Horizontal Form Flow Chart (H F F C) Symbols (*Figure* 3 2)
3 Computer based symbols Somehow different symbols and conventions have been introduced by various com puter manufacturers Figure 3 3 shows the symbols generally accepted

What method one chooses to describe a procedure is a matter of personal preference However in Systems Ana lysis it is usual to use the symbols mentioned in Figure 3 3 The main objective of charting is to break up a pro cedure into its basic components or elements and to bring out their logical relationships so that we may know the sequ ential pattern of activity from start to finish Tha degree of detail to which tha charts should be drawn is purely a matter of raquirements A flowchart helps one to undarstand the shortcom ngs of a systam its bottlenecks duplications wastaful efforts etc To draw a flowchart ona must nacas aarily have a thorough understanding of the systam othar wiae gaps will ahow up and one would notica a discontinuity in tha sequence

When ona has designed a new procadure a similar chart can be drawn and this will help one to appreciata the im provementa made As the symbols used are standard ones a person familiar with them can comprehend a procedure very quickly

While drawing a flowchart one has to be quite clear about the specific activity that is to be charted and the specific purposes of drawing such a flowchart The next stage is to collect all relevant facts related to the problem

Operation
(Describes an activity, e.g., sign, destroy, type, place, etc.)

Inspection
(Examine, check).

Transportation or Movement.

Delay

Filing or Storage.

Figure 3.1. Symbols for flowcharts used in Work Study and O&M.

Origination or Creation of a document

Addition to a document, e.g., Signature

Other activity, e.g., Fold, Staple, Place, etc.

Examine or Check

File

Transport

"IF" condition. Alternative routes

Flow line indicating route of document
Information transfer by reference to another document.

Destroy

Document

Figure 3.2. Horizontal Form Flowchart (HFFC) Symbols.

Figure 3 3 Computer Based Flowcharting Symbols

PROCESS
Any processing function, defined operation(s) causing change in value, form or location of information

INPUT/OUTPUT
General input/output functions, information available for processing (input) or recording of processed information (output)

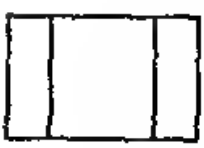
COMMENT, ANNOTATION
Additional descriptive clarification, comment (Dotted line extends to symbols as appropriata)

Connector, exit to, or entry from, another part or page of chart

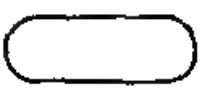
SPECIAL OFF PAGE CONNECTOR
For antry to or axit from a paga

OECISION
A decision or switching type operation that determines which of a number of alternativa paths is to be followed

PREPARATION
Instruction modification to change programme set a switch, modify an index register, initialise a routine



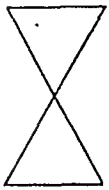
PREDEFINED PROCESS
One or more named operations or programme steps specified in a subroutine or another set of flowcharts



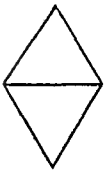
TERMINAL INTERRUPT
A terminal point in a flowchart Stop, start, halt delay or interrupt, may show exit from a closed subroutine

MERGE
Combining two or more sets of items into one set.

EXTRACT
Removal of one or more specific sets of items from a set.



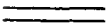
COLLATE
Merging with; extracting; forming two or more sets of items from two or more other sets.



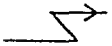
SORT
Arranging a set of items into sequence.

OFF-LINE STORAGE
Storing off-line regardless of recorded medium.

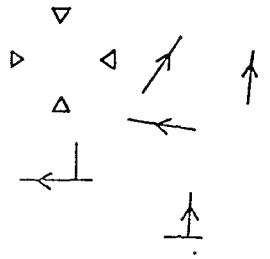
JUNCTION OF FLOW LINES



PARALLEL MODE
The beginning or end of two or more simultaneous operations.



TELECOMMUNICATION LINK
(flow of data shown by arrow(s).)



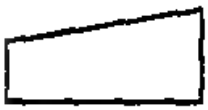
ARROW HEADS AND FLOW LINES

In linking symbols, these show operations sequences and data flow direction. Arrow heads required if path on any linkage is not left-to-right or top-to-bottom.

MAGNETIC DISK

MAGNETIC DRUM

ON LINE STORAGE
Input/output using any kind of on-line storage-magnetic tape, drum, disk



MANUAL INPUT
Information input by on-line keyboards, switch settings, push-buttons, etc

MANUAL OPERATION
Any off-line process (at 'human speed") without mechanical aid

AUXILIARY OPERATION
Off-line performance on equipment not under direct control of central processing unit

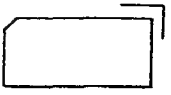
DISPLAY
Information display by on-line indicators, visual devices console printers, plotters, etc

FLOW LINE

CROSSING OF FLOW LINES

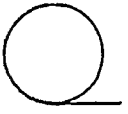
PUNCHED CARD

CARD DECK
A collection of punched cards.



CARD FILE
A collection of related punched card records.

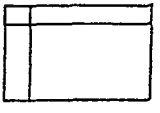
DOCUMENT



MAGNETIC TAPE

TRANSMITTAL TAPE
Proof or adding machine tape, or other batch control information.

PUNCHED TAPE



CORE

The following are some guidelines in flowcharting —

1 The direction of the flow of a procedure or process or system is—

* left to right or
* top to bottom

If one has for some reason to depart from this convention one may use arrowheads to Indicate a sequence of events

2 The flowchart should be clear neat and easy to follow The idea is that there should be a good visual display and this makes for better communication Ensure that there is no room for doubts for example avoid crossed flow lines

3 The flowchart should be correct logically This means that there should be no missed actions and that all criteria branches are accounted for thera are no repeated actions and there is a completed logical flow from start to end

4 If the level of detail is large for a specific portion of tha flowchart draw a separate flowchart to illustrata it and be brief in the main chart Annotatlon and cross refar encaa may be made when the meaning of tha symbol is not apparently clear The primary advantage of a chart is to enable greater comprehension and this objactive should be enabled by any means whatever

5 Evaluate and test the validity of the flowchart by passing through It a simple test data

6 Flowchart symbols may be drawn to any size The best method is to buy a stencil with the symbols cut out on a piece of plastic One has then to trace the symbols on a paper by using a pen and drawing along the cut outs

7 Every flowchart should be identlfitd with a title date and praferably the name of the person who has drawn it (the author not the draftsman)

Some of the advantages of flowcharts are—

1 It enables the analyst to appreciate the logic of a problem Relying on memory is usually a very dangerous thing to do

2 When we draw a flowchart our thinking mechanism is working simultaneously Practice will show how incongruities show up and help us think along new lines and In

new directions. We then begin to experiment with new flow lines and new action symbols until we arrive at an arrangement which we consider as the most logical.

3. A flowchart is an excellent aid to communication and understanding especially as it is possible to comprehend and perceive the logical inter-relationship between the various elements of a problem situation. A well-drawn chart gives a good visual impact and thereby creates interest.

4. Finally, the sequential arrangement of the elements of a system enables one to trace through from the start to the end result along a set of conditions.

III. DECISION TABLES

Though this technique is quite old and has been used extensively in areas like production engineering, it is only about the late 1960s that it began to be used in data processing.

Decision tables are a way of expressing the relationship between data, people, programmes, work, etc., and as such, are of great value in Systems Analysis, because a Systems Analyst is spending most of his time precisely doing just this.

A very simple example is an Insurance premia table. By looking at the Table, one can very quickly say what premium is payable by a person aged 25 taking a policy for Rs. 10,000 maturing at the age of 55. It is possible to arrange data in such a logical manner and make it to help the solving of any problem.

Let us take an illustrative example to understand this better. Assume an Analyst is working in the Inventory control area and has established the following facts :—

(1) The Purchase Manager wants a report about deviations below 10% in the minimum stock levels of some specific items, identified as critical items.

(ii) The Production Manager wants a report one week in advance about any material that may run out of stock or may be short and where supplies to Works becomes difficult in accordance with production schedule.

(iii) The Sales Manager wants a report on all deviations in production compared to schedules to the extent

Though each of these statements is very clear in itself, yet one does not easily grasp the interrelationship between one another A Decision Table will clearly show the facts as will be seen from Figure 3 4

	RULES					
	1	2	3	4	5	6
Dev at ons in M n mum Stock below 10%	Y	Y	Y	N	Y	N
Factory Un t	Y	Y	Y	Y	N	N
Produet P	Y	Y	Y	—	Y	Y
Stockout or shortage of mater al	Y	Y	Y	—	N	Y
Dev at on n product on plan	N	Y	—	N	N	Y
Product Q	Y	N	Y	Y	N	Y
Send Report to Matenals Manager	X	X	—	—	X	X
Send Report to Product on Manager	—	X	X	X	—	X
Send Report to Sales Manager	—	—	—	X	X	X

Figure 3 4 A Decision Table

It will be seen that there are four parts or elements in the above table which can be diagrammatically represented as follows :—

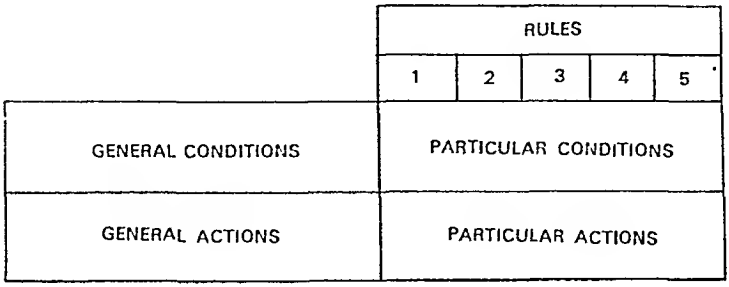


Figure 3.5.

These parts are called as follows :—

1. Condition stub
2. Condition entry
3. Action stub
4. Action entry

These four parts of the Decision Table are separated by thick (or double) horizontal and vertical lines.

The upper left quadrant is the condition stub which lists all the conditions or independent variables that must be tested. Identify all the general conditions and list them in this stub.

The intention is to get all possible combinations of the factors, as this will eliminate the possibility of over-looking an unlikely combination whose omission might cause an otherwise well-planned system to fail. Each set of combinations of various conditions is called a "Rule". The theoretical number of Rules equals the number of values each variable factor may take. These are numbered 1, 2, 3..... ..... Say, for example, we have 3 conditions each of which will have Yes or No as a possibility. Therefore, the number of combinations would be $2 \times 2 \times 2 = 8$ Rules. The Rules are listed in the right upper quadrant.

The vertical column under a Rule is called a Set These are filled in as Y (yes) and N (no) and with a dash (–) if not applicable A separate Rule will exist and has to be filled out for every possible combination of conditions

The action stub (lower left quadrant) lists the possible actions to be taken These actions are the results of the conditions or the combinations of the conditions listed in the condition stub

The action entries are in the lower right quadrant If the particular action is to be taken in respect of a set of conditions mark X in that cell If no action is to be taken the cell is left blank When a particular rule has multiple conditions all the conditions must be fulfilled before a particular action is to be taken

A Decision Table is a tabular display showing all conditions affecting a particular situation and the appropriate action or actions to be taken for each set of conditions It is a method of representing various conditions and alternatives which are used to bring together and present information needed to express the decision logic in a manner that can be visualised easily and understood without difficulty By indicating alternate courses of action under various combinations of conditions a decision table helps an Analyst to think logically through a problem

It must be pointed out here that Decision Tables contain much less information than flow charts The main objective of a Decision Table is to express relationships and there is hardly any other significance to the order in which the conditions rules or actions are expressed Relationships are expressed in flow charts also but it is not as clear or obvious as in a Decision Table A flowchart in addition presents a procedure i e the sequence of actions and the final decision is clearly stated A Decision Table has the advantage of being easily understood by a layman because it is the same as a Railway Time Table or a Price List It can also be used for the verification of logical consistency and completeness which is not easily possible in a flowchart

The production of a flowchart is a creative effort and a good flowchart can have a great impact on the systems effort which will certainly be far greater than that of a deci-

sion table. However, a flowchart by its very nature cannot be exhaustive.

From these considerations, one may draw the following conclusions as to which to use—

1. A flowchart is ideal in a simple straight forward problem.

2. In a complex situation where the input information is known to be or suspected to be incomplete, use a Decision Table.

3. Where the situation warrants, first prepare a Decision Table and from it derive one or more flowcharts for the most suitable solutions.

4. For presentation to Management of an Analysis, a Decision Table is usually favoured.

A decision table form is included in Appendix 2 (Form 1).

IV. SIMULATION

As a technique, simulation used in the right circumstances, will be of great benefit to the Systems Analyst. The technique can be used for selection, analysis and design of medium size to large systems.

In simulation, as the literal meaning of the word implies, we create an artificial situation which has all the characteristics of the real situation and is, therefore, representative of it. We then test this artificially created situation as if it was real. Quite obviously, the greater the resemblance of the artificial situation to the real situation, the greater the benefits of the simulation will be. However, we can only aim at a total resemblance of a real situation; we can hardly make it 100% the same, unless, perhaps a large expenditure is incurred, and it is quite obvious that such large expenditure will hardly be justified. So at best, we may expect a reasonably close resemblance which, in most cases, is adequate to obtain meaningful results.

One might quote an example of simulation, which we must have heard quite often, that of the training given to the astronauts who went to the moon or travel in space. The actual conditions in space or on the moon, e.g., weightlessness, lack of oxygen, etc., are simulated on earth so that these

spacemen might practise as if in a real life situation Similarly, airline pilots are trained in a simulator where they sit in a cockpit and all the conditions which they may encounter are projected on a screen They have to manage the controls on the basis of this artificially simulated situation Training in this manner costs probably a twentieth of training in a live situation and of course there are no risks as in a real situation Simulation is resorted to for various types of situations, e g for river control systems for road traffic and even in medical research

Simulation used in business systems follows exactly the same principles and is more or less the same Let us take a simple case of en Inventory Control system We do not know what is the best method to be used for reorder or whet should be the buffer-stock level and so on We can construct a simple system and try out various methods for e few selectad items in a single store We cen then test the result produced by each method based on, say, the ectuel figures for the last six months or mey be ertificielly created figures which are typical We can then determine how much stock out we heve expanenced, how much money we have locked up in inventory, etc This exarcise will give us a clue es to the bast system thet we may edopt

One shortcoming of the simulation technique is thet it will only give you the comparative merits of the system we hava actually tastad It cannot giva you the best solution, unless the best solution has also been one of the systems tested The ability of the Analyst to think out various alternatives and foresee an optimum solution, will determine how good the final choice is

The following steps are part of the simulation technique

* Identify the system to be tested
* Prepare a simple system for testing
* Create the input data representative of the actual problem to be tested
* Test the system input date
* Find out the output
* Make a Report
* Test all the methods (Decision Rules as per Decision Table)

* Modify the method (Decision Rules) if felt necessary.
* Make Reports.
* Compare the results of each Decision Rule.

As we all know, the decision making in modern Management is characterised by a consideration and evaluation of various alternatives. Simulation is also just that, but what makes simulation valuable is its connection with the computer. Firstly the computer can give us the results with tremendous speed and this in turn means that we can test out a very large number of possibilities which would have been impossible in a manual system.

SYSTEMS INVESTIGATION FILE

It is very necessary for a Systems Analyst to maintain a proper file of all the documents used in the system. Such a file serves many purposes, the chief of them being—

(i) It is a single reference source where all the relevant information relating to the system is available.

(ii) The proper organisation of the information is made possible.

(iii) A lot of duplication of effort is avoided when everything is in one place.

The contents of the file would include—

1. The request for investigation.
2. Terms of reference.
3. A full and complete description of the existing system.
4. The requirements of the revised system that is proposed, with full details of the system.
5. All the working notes as are relevant and necessary.
6. Flowcharts, decision tables and narratives.
7. All the standard forms, e.g., form questionnaires, in addition to samples of forms used in the system.

The formats of the following typical forms used in Systems Analysis have been given in Appendix 2:

Form 1—Decision Table Form

This form is used for making a Decision Table as described earlier in this chapter.

Form 2—Output Analysis Chart Form

This form is used for analysis of documents in terms of their contents

Form 3—Operation Summary Form

This form records the work of an individual, i e , flow of information along a particular point which we would identify as the individual

Form 4—Document Specification Form

This form describes the documents used in a procedure

Form 5—Contents Form

On this form the items which occur within a document or form i e contents of tha form ara listed in detail

Form 6—File Specification Form

This form contains the details of files and used in tha syatem

Form 7—Processes Form

This form gives particulars of the activities which take place within the system

Form 8—Statement of Requirements Form

This form provides for a specification of each result It states tha derivation of all variable items the destination of the information and the time it should be mada available

Form 9—File Description Form

The form is used to describe the attributes of a file as a whole that is its size sequence (at various stages if required), frequency etc

Form 10—List of File Items Form

This form is used for listing out in minute detail the contents of a file

Form 11—Derivation of File Items

This form is used to qualify the components of the file in the list of file items

4. Inputs and Outputs

I DESIGN OF INPUTS

The prime task of an Analyst is to capture (or record on file) the raw data in a form suitable for computer inputs. In fact, this is the essence of the problem and one which will take most of his time.

There are three main sources for the inputs in a computer system:

(i) **External data**, such as material used, quantities used, hours worked, etc. These are the basic inputs and one of the main reasons why the system exists. Such external data can be divided into two parts—current data and file data. It is usually a problem to identify both and bring them together.

(ii) **Internal user data**, such as requests for special action, questions, etc. This type of data enables the user to communicate with and employ the system.

(iii) **Internal system data**, such as procedure control, programme instructions, etc. This type of input is limited in extent but vital to the physical operation of the system.

Some of the objectives of input/output design to be achieved are—

(i) The total input volume should be minimum.

(ii) The total input to be prepared manually should be minimum.

(iii) The input design should be such that the person

preparing the input should not find it difficult or cumbersome to do so

(iv) The steps involved from the origin of the data to the final input to the computer should be the minimum possible

(v) The outputs must be minimum to meet the overall system objectives

(vi) The output must be designed in such a way that it is easily understood

(vii) The output must be in accordance with the actual needs of the user

Let us consider how these can be achieved First input volumes have to be reduced To start with only vari able data should be entered accompanied by the minimum constant data For example in an inventory control system only tha quantities need be entered with the material coda numbar not the name or size or quality of the material etc Secondly repetitive data should be antered into the systam only once In an Inventory Control System enter such data only once Thirdly only exceptions need ba entered into tha system For example in a payroll systam if 36 houra consti tuta a normal working week only exceptions to the figure need ba enterad

Whenever there is a large number of repatitiva infor mation to be entered into a system it is advisable to auto mate the work For example one may have card codes in a card input merely to identify the card type Another example is the use of standard forms especially designed for this purpose

One of the important principles is to simplify the clerical procedures in data capture If this is complicated errors are sure to creep in Logical sequencing of data is a simple example

It would be very desirable to use well developed O & M techniques to ensure that clerical procedures are efficient The computer input system might represent a constraint on the design of the clerical system but it is well to realise that both must match each other Hence the need to emphasise that neither of them should be designed in isolation

The objective in condensing the steps between the

origin of data and the final input is to reduce delays and decrease the possibility of errors in transcription, pre-processing, etc.

Input Methods

The basic steps are:

(i) **Original Recording:** At this point the documents relating to the original transaction are dealt with, e.g., the filling of an invoice.

(ii) **Transmission:** The data moves from the point of origin (say a warehouse) to the Data Processing Centre.

(iii) **Transcription:** The original transaction is transcribed in a suitable input medium.

(iv) **Verification:** It is verified that the transcription has been done correctly. This is vital because it can result in wrong outputs.

(v) **Sorting:** The inputs are recorded into a sequence that is as per the computer programme.

(vi) **Control:** Here it is ensured that all the original records have been transcribed.

(vii) **Input:** The final stage is now reached. The data is assimilated by the system after preparation and before processing.

It may happen that all these functions may not exist in a particular application or may be in a different sequence. As stated earlier, it is desirable to reduce the volume of the input and reduce and automate the stages in its introduction into the computer system.

The chief methods used for data inputs are—

(i) Punched cards.

(ii) Punched paper tape.

(iii) Magnetic tape encoders. These are capable of writing data directly onto magnetic tapes.

(iv) Indirect keyboard machines. Here, a paper tape is produced as a by-product of a normal keyboard operation to prepare a hard copy. These are found in accounting machines, cash registers, etc.

(v) Mark-sensing reader punches. (Pencil marks are made in predetermined positions on a punched card and these are converted automatically into punched holes).

(vi) Magnetic ink character readers (MICR) These translate the stylised characters printed in magnetic ink on documents into direct computer inputs

(vii) Optical Character Recognition (OCR)—These are somewhat similar to (vi) above except that printing ink can be used

(viii) Mark readers

(ix) Document readers

(x) Remote input units

(xi) On line terminals

Analysts must examine which of these methods is most suitable and appropriate for the specific purpose Two of the most popular and probably the best are punched cards end paper tape They have several d stinct advantages over the others Some of these advanteges ere

Punched cards

(i) Card files can be easily updeted by removing or in serting cards Faulty cards can be replaced with eese

(ii) Cards are a form of computer input and can be read easily by man and machines Since they can be interpreted visually they form parmanent visual records

(iii) Cards can be used as working documents since they are unit documents e g when an invoice is made out e punched card may be sent along with it and the customer requested to send it back along with his cheque

(iv) Because they are unit documents they are parti cularly suited for off line processing on electro mechanical equipment such as for sorting counting or merging

(v) Use for programming input is easier

Paper tape

(i) The length of each record is unlimited

(ii) Computer input can be faster than with punched cards

(iii) Easier to store since it is more compact

(iv) Useful for transmission by telex

II. DESIGN OF OUTPUTS

Computer outputs are what the user is concerned with in terms of the System and a good output, therefore, gives the maximum advantage of a computer. If the output is bad or unintelligible, all work in producing it is lost and the user is most likely to hurl it into the waste paper basket.

Often preprinted stationery is used for printing out outputs. In such cases, care should be taken to ensure that output design is excellent. As much attention should be paid to the output design as to the design of input forms. Very often, a line printer prints out a copy. The Analyst must communicate the exact output requirements of his system in a standardised manner to enable programmers and users to be aware of what is finally to be produced.

The basic equipment for production computer output in human understandable form are :

1. Line printers.
2. Character printers.
3. Visual display devices.
4. Off-line peripheral devices which produce micro-film directly from magnetic tapes.
5. Punched cards.
6. Punched paper tape.
7. Magnetic tapes.
8. Digital analogue converters.

As in the case of inputs there are three divisions in computer outputs :—

1. External results, i.e., those intended to go outside the user's organisation, for example, Invoices, supplier's cash credit account, pay slips, tax return, etc.

2. Internal results, i.e., those used within the user's organisation.

3. Internal system results such as operating statistics, file usage reports, system control reports, etc.

There are as in the case of inputs, specific points which the Analyst must specify for each output required from his system, e.g.,

1. Identification.
2. Contents and format.
3. Frequency of production.

4 Output volume expected

5 Conditions which give use to the production of the output

6 Output sequence

III FORMS DESIGN

The design of the forms used plays a very significant role in the efficiency of systems work An Analyst in the course of an assignment would be required to design several new forms or alter the design of existing forms to take care of the needs of the new system From designing is a specialised job and it would be worthwhile to enlist the services of an expert (usually available in the O & M Department) to design the necessary forms The basic principles of forms designing are given here to enable the reader to have a fair idea of this important topic

Every form should be suited to serve a specific procedure or a specific purpose and the conditions in which it is intended to operate Some of the points to remember to start with are

(1) Have as few types of forms as possible—The intention is to design a simple system If one has more forms complexities arise and clerical operations tend to become more difficult.

(2) Let one form serve as many related purposes as possible—If all the information required for an operation can conveniently be gathered on one sheet of paper so much the better

(3) Do not have too many operations performed on or from one form—If there are too many operations it suggests the form is too complicated If there are too many clerks needing the same form it means delays and bottlenecks and this will have an adverse effect on efficiency

(4) Make forms easy to identify, to enter and to use—It must have an appropriate title and the design should be such that it is convenient to enter data in it, i e there should be adequate spacing and the column must be in logical sequence etc

(5) The forms which are to be used together should be designated together—If information from one form is to be

copied into another, then the sequence of the columns must be the same in both. If this simple principle is ignored, it can cause no small amount of clerical errors in copying.

(6) The quality and appearance of a form should be suited to its purpose—This is an important matter which is usually ignored.

Before we start designing a form, a few relevant questions must be answered:

(i) What is the true purpose of this form? Is the purpose valid and is it really necessary? Does the form fully accomplish its purpose? (To start with one must be thoroughly familiar with the clerical procedure involved).

(ii) Can some other existing form serve this purpose or can an existing form be modified to suit this purpose?

(iii) Can the form be combined with some other form?

(iv) Are all the necessary copies included? Are all copies really necessary?

(v) What is the information that will be entered on the form? Who will enter this and how? (Manually?, on a typewriter? with a Bradma machine?), and under what conditions? (standing besides a machine on the factory floor? on an office desk?).

(vi) What are the allied forms? Have these been studied?

(vii) What will happen to the information once it has been entered on this form? What will happen to the form after it has been filled, i.e., who will use it and how?

(viii) How will it be preserved and for how long?

The major requirements for a good form are:

1. It must afford the easiest possible method of entering the data on the form.

2. It must afford the easiest possible method of using the data after they have been entered on the form.

3. It must reduce the tendency to error in entering or using the data.

4. It must create a favourable attitude on the part of the clerical worker towards the job on hand.

5. It must make for paper and printing economy within the limit set by efficient clerical use.

Some of the basic rules in regard to form design are—

1 It must carry a title This title should be appropriate and be sufficiently descriptive of its use and application to make it identifiable by all concerned

2 All forms should be controlled and a code number must be given to each form

3 If accountability of copies is necessary e g Invoice forms then there should be a printed serial number on the form This is preferably printed on the top right hand corner in a box

4 The form must carry suitable instructions on how to fill the form i e what to include and what to omit instructions on distribution instructions on retention period of the form etc

5 There should be a date line and information indicating the span of time covered by the Report e g Sales for the quarter ending 31st March

6 The source and destination (From To) must be clearly set forth as introductory information

7 Logically related groups of information must be arranged in sequence

8 The form should facilitate entry of data The method of entry is important—is it typed entered by hand or printed by a machine The spacing is important Use of boxes is usually recommended

9 The form must be designed to facilitate to the greatest possible degree the correct efficient and effective use of the data after they have been entered in the form

10 The form should be designed to prevent in so far as possible clerical and reading errors and facilitate punching by key punch operation

11 There should be a proper conclusion e g provision for necessary signatures with names dates and designations and other identifying data

12 Consideration must be given to the methods of filing the form during its active or inactive life

A book which may be consulted in regard to forms designing is The Knox Standard Guide to Design and Control of Business Forms by Frank M Knox McGraw Hill Book Co U S A

5. File Organisation

The term "file" in a computer system refers to records containing information. There is obviously a limitation to the information that a computer can store in its memory for performing a limited task. Therefore, the system uses an external storage.

There are two types of files—

(1) a reference file, for example, a list of the materials in stock with their code numbers; and

(2) a dynamic file, showing actual stocks at a point of time.

Before we construct a file we have to decide—

(1) what storage medium to use for the files, e.g., magnetic tapes or disc, etc.

(2) how the records should be organised within the file; and

(3) what items will be included within each record.

1. Storage media

The media for holding computer files can be both paper and magnetic. The paper media are punched cards and punched paper tape. The magnetic media are magnetic tape, magnetic disc, magnetic drum and magnetic card. The most commonly used are punched cards and magnetic tape.

To choose the medium, the following points need to be considered:

1 Speed with which information can be moved from the medium to the computer For example, if the reading speed of some peripheral device is slow, there is no purpose in having media with fast internal transfer speed

2 The volume of information which the medium can conveniently accommodate This is especially important when the volume is expected to rise rapidly in the future

3 The possible ways in which the individual records can be arranged for access on to the chosen medium Different applications have different requirements in terms of access to files

One of the problems usually faced in all the media is that the structure of the file medium might not match the structure of the information To cite an example, a punchad card has usually 80 characters, while a file record may have more than 80 characters In such a case, two or more cards might be required to hold one record

Record layout

The physical arrangement of the data elements of a record is called the layout of the record In this, there are several differing requirements to be catered to—

(i) the person or machine that creates the source data,

(ii) the process which translates the data into machine readable form,

(iii) the storage medium, and

(iv) the processing requirements for which the data will be used

Quite often these requirements may conflict one with another For practical purposes, it might be advisable to give the user's problems top priority consideration because his acceptance and the ease with which he can use the system will determine the success of the system

Some basic principles should be observed for design of records—

(i) **Punched cards:** There are two uses of punched cards as files They may be used as the file storage medium and they may be used as a means of creating a file in another medium, say a magnetic disk Some of the factors to be taken into account while designing card record layouts are—

(i) The identity of the file and data must be on every card. If this is missed, the cards will get jumbled up and it will be impossible to retrieve them. The card type code must be located at a fixed position of the card, for example, in the first four columns.

(ii) Colour coding may often prove useful to prevent accidental mixing up of card files.

(iii) To identify the location of a card within a file, a part of the data is used, e.g., employee code number, component part number, etc.

(iv) Usually the tendency is to confine the length of the record to the card capacity, e.g., 80 characters. Where the record length is bigger and more cards are used, the file and record identifying codes (stated in (i) above) must occupy the same positions on the cards.

(v) Where there are more cards for one record, these should be serially coded as 1, 2, 3 ..... to be certain that the maintenance of the record is proper.

2. **Magnetic Tape records**

(i) These are by nature contiguous. File identification codes need not, therefore, be repeated on every record. This information can be held in a single file header record which may also include information about the retention period of the data on the file.

(ii) In tapes, the data can be coded in accordance with the machine requirements. This is not possible in cards.

(iii) Tapes are very long usually 2,400 feet. Buffer areas are usually left for efficient transfer of data. In choosing the record length, it should be ensured that it is not too unwieldy for processing.

3. **Direct access devices**

(i) For other magnetic storage media, most of what was said about tapes will apply.

(ii) Consideration of record size may assume greater importance here with respect to the efficiency with which data is transferred.

(iii) These devices are faster than tapes in respect of data retrieval and, therefore, enable quicker processing.

Fila organisation

Files are organised basically in three ways—sequential, random and list

(i) Sequential organisation. There is usually a common factor in a set of records let us say 'sales area" for purpose of sales statistics These can be coded as 1, 2, 3 This is called the key field or key of the record This need not be the card identifier code mentioned earlier

All the cards will be arranged sequentially In terms of the key fields—in the above case in terms of the sales area codes—1, 2, 3, 4 etc

(ii) Random organisation· Here, the fila is dispersed in tha storage device in a random manner The method of retrieval is quite simple This is done by having an index Take the sales area example —

Sales Area Coda	Location
1	0161
2	0359
15	0200
29	0712 etc.

(iii) List organisation. In this type, the logical end physical organisation of a fila are seperatad by the use of pointers Each physical record has a pointer to the next logical record A file can be created by adding a new record to the end of tha fila in a sequential manner In effect, it becomes a sequential fila with the key being the date of addition of the new file The logical sequence of the file is maintained by amending the pointers in the affected records in the file and incorporating a pointer into the new records The file header record will of course incorporate a pointer to the first record

Choice of file organisation

Several factors affect the choice of file organisation and soma of these factors might be conflicting Soma of thesa factors are the availability of the storage media, the hardware used, the possibility and efficiency of programming, the operating system, the size of the file and of the record, tha fre-

quency of updating of the files and the volume involved, the cost of files, the space required and finally the security of the files.

Cost implications are most vital and it is very necessary to evaluate costs before choosing the file organisation structure. This is important for one main reason. The structure of the file will have a direct effect on processing time required for running a system. Similarly storage space costs must be taken into consideration.

6 Systems Design and Implementation

From the Input Output and files, one will draw conclu sions in regard to the processing and computationel requirements that will provide a link between them This is the sys tems design The enalyst will design the system end get the necessary epprovel of Menagement efter expleining the deteils

There ere bound to be severel factors effecting the design end some of these would be the constreints imposed by the user of the system or the limitations of the computer itself or those of the softwere

The end result of the design work is the production of e programme specificetion This document links the Anelyst to the programmer The programme specification should therefore be absolutely correct end it would be desireble to adopt e standard method for doing this The following are the points which inveriably should be included in a good pro gramme specification —

General

1 The title or name of the system and its number
2 Date
3 Name of Analyst
4 User s name and designation
5 Contents
6 Amendments record (number authority, date page or other reference and description)

7. Time schedules for testing and commencement of system.
8. Procedures covered (main and allied).
9. Departments affected.
10. Inputs (medium, description, source data, volumes).
11. Outputs (medium, description, use, volumes).
12. Files (Media, description, use, volumes).

Detailed description

13. Flowcharts of clerical procedures.
14. Narrative and detailed description of procedures, individual responsibilities, frequency of activities.
15. Codes, controls, data handling and transportation.
16. Flowcharts of output and distribution procedures with full narrative and description.
17. Flowcharts of computer procedures with all narrative and description.
18. Full details of changeover procedure including the conversion of files, trial runs, parallel runs with existing system and changeover.
19. Utilisation of equipment with full description—computer, peripherals, ancillary equipment, full details of utilisation of hardware.
20. Document specifications—description of each document including name, number, purpose, how and where filled, data elements, origin, frequency, etc. Enclose samples of all documents.
21. Specifications of printouts—full description of formats including references, names, programme numbers, printlines, field sizes, and lateral and vertical spacing. Also narrative of print-out including purpose, stationery to be used and other special instructions, distribution, routing, etc.
22. Specification of files.
23. Description of System test data showing layouts of input and main files and the expected results.
24. Procedures relating to the programme (introduction, start, main and end procedures, dump and restart procedures).

The system after it has been designed and programmed has to be tested. Here the Analyst has to play a very sen-

sitive role as he has to convince all concerned about the use fulness and worth of the system which he has designed

The object is to ensure that the system fulfils all the tasks which were originally intended Each programme can be separately and jointly tested The saquence of the testing should be programme oriented Corrections where needed will be marked out and rectified

To make the test a success the Analyst must keep in constant touch with programmers to see that the test data is effective The complete system must be tested All the documentation connected with the system must be carefully maintained This is particularly important since in the pro cess of system maintenance after initial implementation tha system will require further testing and modification if neces sary

Implementation

One of the important tasks of tha Systema Analyst is to ensura that tha new system is implementad in a succeasful mannar This task involvas co ordination and good organi aational ability Thara are various aspects to ba considerad both in ragard to the computar and the non computer psrts of the syatem It should be ensured that the implementation is amooth that the machine time is not wasted by manual errors and that all concerned are involved and appreciate the change

Whila implementing the system the main criterion is the thorough knowledge of the system and it is only the Systems Analyst who has this thorough knowledge and therefore to a very great extent the success of the implementation depends on the Systems Analyst s ability He must consider all aspects including the effects of the change

It is necassary to ensure that all people who are concern ed are aware of their respective roles in regard to the system As stated earlier it might be necessary to run a parallel sys tem for sometime before the new system takes over fully The staff in the user department must be made fully aware of the change and must be geared up to adopt this change smoothly It would therefore be advisable to have a time schedule for various stages of implementation and deadline

for the full adoption of the system. A PERT network might be desirable in the case of a complex system.

In most cases, it might be also desirable to have a handbook (in the case of a complex system) or a detailed office order (in the case of a simple system) describing the system in full and allotting the various duties and responsibilities to the various people. In most cases, the staff involved will have to be given training in regard to the procedures involved in the new system. This training should be monitored and the actual performance should be appraised.

One of the chief problems that arises is in regard to file conversion which involves problems of fact finding, data capture, clerical procedure design, form design and programme specification. It depends on the old and new recording media and may involve card indices, folders or binders of the manual system, punched cards, disks, or tapes of the machine system, master files or specialised files containing records and a centralised or scattered filing system. The result of conversion job would be the final file as specified in the programme. Each field on the file will be identified with a source document and sometimes information from a number of sources would be drawn together to make a file.

The change-over might be a direct one, or have a parallel simultaneous run or a pilot operation. A direct change-over is recommended only when the system is completely new and has no relationship with any previous system. If there is such a relationship, it would be better to have a parallel run simultaneously with the old system so that results could be cross-checked and it is ensured that the new system is free from any trouble.

A pilot operation can be usually of two kinds. One method uses the new system with the previous periods' data so that the results can be checked with what has already been worked out before. Such a test is easier than the parallel running. The alternative system is where a new system is introduced on a piece-meal basis and phased out in gradual stages.

In regard to the implementation phase, some of the points which are to be carefully noted by the Systems Analyst are:

1. proper co-ordination in regard to the change-over,
2 proper and complete communication with all concerned with the system during the change-over,
3 correcting and controlling errors which may appear,
4 ensuring that all people affected by the changes have understood and accepted the change, and
5 getting a complete feedback during the test runs and ensuring that everything is perfect for the final change-over

Part Two
DATA PROCESSING

7. History of Data Processing

As is only too well known, man's trip to the moon would not have been possible without the aid of the modern computer. In fact, most of the spectacular advances in science and technology that have taken place since the last war, owe very much to the versatile capabilities of computers. It would be worthwhile to have a quick glance at the history of data processing, which is what computers do.

Since the earliest days, man has been wanting to escape the drudgery of calculation. The first mechanical aid for simple calculations was the ABACUS. The earliest one dates back to the 6th century, B.C. in China. It consisted of a wooden frame with balls strung on wires. Another version was a table with grooves in which the counters were free to slide. (Egyptian—2nd century, B.C.). Then there were the Roman, Korean, Japanese, Turkish, Russian and American versions which, by and large, followed the same principle for computing.

To Blaise Pascal of France goes the credit of inventing in 1671, the first digital calculating machine. It is called digital because it carried out arithmetic operations—adding, in this case. The machine performed multiplication by repeatedly adding.

Several attempts were made in the 18th century to produce a reliable machine for commercial use, but except for some stray examples, most of them were not successful.

The English mathematician, Charles Babbage, realised that if the entire process of arithmetical calculations could be

automatized a great speed up could be ach eved In 1923 he invented the difference engine a machine which could calculate and print tables of functions by using finite differ ence techniques In 1933 he conceived of the idea of a universal digital calculator but unfortunately it took almost a century to build such a device The reason was that tech niques of fabricating metal parts to very close tolerance were unknown then Babbage had introduced programme con trol into computer history i e the possibility to make machines carry out long sequences of arithmetical operations without human intervention

One of the most significant contributions to data pro cessing was made by Herman Hollerith who worked in the Census Bureau of U S A when he introduced the punched card in the U S census operations of 1890 He found e means of using the card for storing numerical data by pun ching holes in the cards for sorting these cards mechanically and for analysing the data stored in them These techniques which were applied In the U S census of 1890 were applied also to the British Census of 1911 Hollerith s ideas were later perfected by Intemetional Business Machines (IBM) and thoae of his assistant Powers were developed by Remington Rand Co

The basic device is e card 8'X3' containing 80 columns Data is transcribed into these cards by punching holes in them In the IBM the cards are read by means of electrical contacts through the holes and the machine then manipulates the data by performing various anthmetic and logical opera tions at fantastically high speeds The operations include sorting edding subtracting multiplying reproducing listing collating etc in fact all the clerical operations required in modem business

The back bone of business accounting was the punched card machine till shortly after the World War In 1944 IBM s automatic sequence controlled calculator was Installed at Harvard University It was a joint effort of IBM and Howard Aiken of Harvard Called Mark I the machine used punched tape instead of cards end operated on the principle of sequential control as developed by Babbage

In 1945 Dr John Mauchly end Presper Eckert Jr from

the University of Pennsylvania built a general purpose, high speed digital calculator called ENIAC (Electronic Numerical Integrator and Automatic Computer). It contained 18,000 vacuum tubes and consumed 100 Kw of electricity and occupied a room 100 feet in length. It could perform 5000 additions in one second and a multiplication problem in 2 to 8 milliseconds. The internal operations in this machine were conducted by electronic impulses generated at a rate of 1,00,000 per second.

John Von Neumann, renowned as one of the world's great mathematicians, conceived the idea of a "stored programme" to replace the cumbersome and complicated wired control panels of ENIAC. One of the first computers using this concept was built at Cambridge University, U.K. in 1948, and was called EDSAC (Electronic Delay Storage Automatic Calculator).

The next milestone in computer development was UNIVAC-I, built by Remington Rand in 1951. This machine is recognised as the first computer to be used in business applications. UNIVAC I for the first time used magnetic tape as a means of input to the computer.

In the early 1950s, IBM introduced its 701 computer, its first large scale electronic data processing system. Its internal memory was twice as large as that of the UNIVAC I and was twice as fast.

The period between 1954 and 1959 saw a boom in the world of data processing. Numerous manufacturers developed computer systems.

One of the most important events affecting the computer was the development of transistors which were introduced by Bell Laboratories in 1948. The transistor performed the same functions as the vacuum tube, was very much less expensive, required little power and generated much less heat than the vacuum tubes. By 1958, the transistor had literally replaced the vaccum tube and as a result, computers became smaller in size and in cost, and could be operated much faster. By 1960, U.S.A. alone had more than 5000 computers.

In 1959, IBM had introduced its 1401 series of computers which literally dominated the business world till 1964,

by which time they had sold almost 7 000 such computers This computer was primarily responsible for the changeover from the Unit Record or punched card data processing ins tallation to electronic data processing systems In terms of cost it was almost equal to that of the Unit Record machines

In U K the International Computers and Tabulators Ltd was formed in 1959 In order to counter the success of IBM the ICT purchased expertise from other stalwarts in the field of electronics like GEC EMI Ferrante etc This by itself proved inadequate The British Government and the computer industry in U K agreed that it would be in the overall interest of Britain for the various computer companies to operate as a single unit and pool their resources This decision resulted in the formation of International Computera Ltd in 1968

In India Hollenth had its first unit record installation in the Railways in 1922 Business grew quite rapidly and seve ral machines were installed all over India Falling in line with ita parant company it merged with Power Samaa Computer India to form the Intarnational Computers and Tabulators (India) Ltd in 1959 The first computar an H 1201 waa installed in India as early as 1959 by ICT at tha Indian Statis tical Institute Calcutta

The computers built between 1958 and 1964 are refer red to as the second generation computers They were used for scientific and mathematical applications as also for business type applications The need arose for much faster internal operations and calculating speeds for scientific appli cations compared to business applications and this induced IBM and other computer manufacturers to produce more sophisticated machines to cater to the needs of science Many major advances in computer design and technology occurred about 1964 when the third generation computer systems were introduced The characteristics of this sys tem were

1 Business and scientific problems were processed within one single computing system

2 Programmes or instructions written for smaller com puters were understood by the larger systems

3. The computer capabilities were utilised to the maximum extent.

4. They had more high speed and retrieval capabilities; and

5. Very great improvements took place in terms of facilities for communication from remote terminals.

The third generation computing systems are characterised by what is called "integrated circuitry" which utilises extremely small chips of silicon mounted on a ceramic or glass substrait, segments of which have been metalised to form an electronic circuit similar to the transistor found on the printed circuit board of the second generation computing systems. Integrated circuitry made possible a very much higher speed compared to transistors.

Third generation computing systems make use of several new systems concepts, for example, multiple programming, i.e., the concurrent processing of several jobs at the same time within the computer; real time capabilities which means the processing of data as and when they come; and the use of interrupts which allows current operations to be interrupted on exceptional conditions but permits continuous operation of the system without any manual intervention.

As mentioned earlier, the primary motivating force behind the development of the electronic computer was the desire to process and handle information in faster and more efficient ways. Computers collect, record and process vast amounts of information. The Banking and Insurance industries were quick to realise the possibilities of computers and introduced them in a great way to speed up their operations. Computer simulation in business operations also found great favour and added considerably to better decision making.

Computers can collect information and file it for future use, can analyse information, compare facts and figures, find equals and unequals, classify information, or abstract useful information from a body of otherwise meaningless data. It is used in medicine for diagnosis and in scientific research. In Biochemistry computers are used as a sort of mathematical microscope. In astronomy, its applications can be considered just fantastic, because the calculations involved are really astronomical. In the petroleum industry, computers

have played a very important role in the matter of discovery, drilling, refining, marketing, transportation, etc Airlines use computers for ticket reservations and an airline clerk can, by merely pressing a button, get information relating to reservation in a particular flight in a matter of seconds, from a central computer situated, may be, hundreds of miles away

What the computer has achieved is to squeeze literally, months or sometimes years of computational time into a matter of a few minutes Modern computers can execute millions of instructions per second It is estimated that a computer can, in one minute, perform computations which one human being would take 4,000 years by manual method

The computers hava made this world a much better placa to liva in and, perhaps in the future, we may find computer applications which are probably not dreamt of now At any rate, it is the modern man's greatest tool for scientific progress

8. Management Information Systems —An Overview

Need for information

The decision-making aspect of the Management process is most vital in the area of utilisation and disposition of resources, i.e., of men, money, machines and materials. To make sound decisions, a Manager needs information—facts and figures, economic data, physical and financial data, etc., providing a base for formulating his plans against which to exercise control of performance and progress.

Such information is usually called Management Information and if the decision is not taken on the basis of this information it becomes a decision by hunch, which has as its characteristics a great element of risk, lack of surety or precision and indefiniteness. It is to avoid this aspect of indefiniteness that it is desirable to adopt what is generally called the Scientific Method whose elements are—

1. Collection and collation of facts in a methodical manner;
2. Analysing and evaluating them;
3. Determining the conclusion that the facts lead to;
4. Provisionally testing the conclusions; and
5. Taking a firm decision on the basis of the test.

Information is the life blood of Management. A Management Information System or MIS as it is popularly called, can be defined as a systematised approach of furnishing timely, adequate, accurate information to the right person

in the managerial hierarchy, with a view to assisting him in taking such decisions as will optimise productivity of available resources and attain organisational goals effectively The efficiency of an organisation is, to a great extent governed by the pertinence and regularity of the information provided to those who exercise the functions of Management The ultimate effectiveness of this information is in itself dependent upon the form and timing of its presentation

What is information?

Information is processed data In other words, data is the raw material from which information is produced The term data includes all facts and figures or description of an idea, object, condition or situation Every field of activity produces data—attendance records, production outputs, absentee statistics, productivity figures and quality specification, to name a few By itself, mere data is often inadequate for a Manager to take decisions Take for example, a production report for 1st July 1978 which shows that 4000 barrels were produced during the day But if it is also stated that 4600 is the standard production, then it becomes meaningful information on which the Production Manager can act The difference between data and information, therefore, primarily is one of usefulness A compilation of raw data by itself does not provide enough knowledge on which to act It must be converted into information

Another feature is that from the same data as base, different people require different information Let us take the above example and see the different information needs of different people

(i) Production Manager	Compare actual production with standard production
(ii) Sales Manager	Barrel availability to delivery commitments made to customers
(iii) Materials Manager	Consumption of raw materials to actual consumption and so on

Every data may have potential information value but what constitutes information for one person may have no

value to another and also to the same individual the information may have lost its significance under different circumstances or at a different point of time. For example, the information relating to the production figure of 1.7.78 may not have value for the Production Manager on 1.8.78.

Information, therefore, consists of selected data which has been organised with special reference to the needs of the user, the problem, the time, place and specific function. The primary function of data processing is the conversion of data into information.

Management Information Systems (MIS)

Data processing by computers has been extremely effective for various reasons, the chief of them being that very large volumes of data relating to accounting and other transactions can be processed at very great speeds. Earlier, most of these computer applications were, what one might term, the solving of record keeping problems. However, in recent years, increasing attention has been focussed on computer applications providing information for policy making, management planning and control purposes. The emphasis lay in responding to information requests and providing accurate and timely reports for Management use, e.g., in purchasing, inventory control, production scheduling, sales analysis, and, in fact, all facets of business activity. Specific Management Information Systems are structured for specific needs and these relieve Managers of much tedious analysis of data, focus their attention promptly on matters requiring decisions and allow them to concentrate on more productive tasks.

Information systems in a business organisation can broadly be classified into two categories, i.e., financial and non-financial.

The non-financial Management Information System can be further classified into various functional categories, e.g.,

1. Marketing or Sales Management Information System.
2. Manufacturing or Production Management or Operational Information System.
3. Personnel Management Information System, etc.

Under each of these, there can be several independent sub systems In a large distribution organisation for example transport can form a separate information system There may be separate information systems for inventory control production control etc What is important to rea lise is that they serve specific purposes and specific users

Information for Management can be classified into two headings

(a) Information supplied at regular intervals for parti cular purposes often upon specific request

(b) Information embodied in routine reports made available at regular intervals in forms which are often standardised

The requisite information the amount of detail and the methods of presentation have by and large to be tailor made for a particular organisation its size its structure and the levels of Management to which the information is rendered in each case

The higher levels of Management will normally require reports that are broad in scope and from which details have been eliminated and where only the salient features have been depicted Information for lower levels of Management should be progressively more detailed and related to specific functions and consequently will be more specialised in scope

Characteristics of a good MIS

Some of the essential characteristics of a good Man agement Information System are as follows —

(i) **Timeliness** Reports which are produced late will be of no value to the user Reports must be in time if they are to permit operational feedback

(ii) **Accuracy** The figures in the data presented should be accurate enough for the intended purpose

(iii) **Usefulness** The report must serve the intended purpose and should primarily contribute to profitability The procedure should provide the user with the information he requires and the information should have a decision making

value. The exceptions or items requiring special attention should be highlighted and not buried inside the report.

(iv) **Efficiency**: A report should be such that a person should look at one place and not many places before finding an answer to a question.

(v) **Necessity**: A question that usually should be asked is whether the work is being duplicated and if the report is really necessary. For example, if some of the reports are prepared frequently, it is worthwhile to know whether they are used all the time or only occasionally.

(vi) **Completeness**: Some of the information requires constantly to be updated, e.g., production problems, changes in customer buying habits, etc. A good MIS will cater to Management's needs of determining in advance the effect of their decisions on such factors as publicity campaigns and increased sales or increased production facilities and inventories.

(vii) **Reliability**: The facts presented should be trusted by Managers. If such faith is not built up, Managers will initiate their own private investigation. For example, sales and production forecasts should reflect in reality the sales trends.

(viii) **Responsibility**: Responsibilities should be defined for each decision process within the total information flow. The boundaries of Management responsibilities should be defined in order to structure a MIS which will efficiently cater to well defined areas of Management responsibility.

Data base

Every information system has a data base. The necessary data is first accumulated and then processed to produce meaningful reports. The smallest unit of data that has meaning to its user is called a data item. Various data items are grouped together to form a record. In customer accounting, for example, the customer's name and address, location, deliveries made, amount billed, cash received and credit and debit notes issued, are all data items. Grouping of the data items pertaining to a customer is called customer record. Grouping of all customer records constitutes a

customer file Grouping of all related files form the data base for a particular Management Information System All records maintained in an organisation forming part of various Management Information Systems is collectively known as Data Bank

Data Processing Systems

Data processing systems deal with the conversion of data into meaningful Management Information Reports Quite obviously, a good information system would require a good data processing system The term 'good' information system is a very relative term In most cases, for example, there would be no great need for speed while in some cases speed of information availability would be of the essence, taking the extreme example of controlling a space craft The data processing system has, therefore to be just suitable for the specific MIS need—not more, nor less To have a very sophisticated large system for a mundane routine need is to waste money unnecessarily on the system It is like using a rifle to kill a cockroach Similarly, to use a very slow system when speed of information processing is very desirable, is equally bad The choice of the specific system would depend on a number of factors, some of which are—

1 Volume of data to be processed
2 Complex nature of the operation
3 Repetitive nature of the operation
4 Accuracy desired
5 Availability of manpower
6 Speed with which the result is desired This again depends upon the purpose for which the information is used
7 Relative cost of the systems

It can, however, be said that the larger the organisation and the larger the complexities of the business operations the greater would be the need for automatic data processing systems

Comparison of manual and machine systems

The advantages of a manual system compared to a mechanical system for Management Information processing are—

1. Manual systems are more flexible. Parts of the systems can be changed or altered more easily.

2. Time tested control methods are used in a manual clerical system, making it fool-proof from the point of view of preventing fraud and misappropriation, particularly with regard to division of responsibilities between the departments and within the department, between various individuals. The problem of security and control of data in a computer system is far more complex than in a manual system.

3. Systems development costs are higher in mechanical systems and changes are more difficult to make than in a manual system. Similarly, due to the need to provide control features for prevention of fraud and misuse, the mechanical system tends to become more expensive.

However, the advantages which a computer system has over a manual system in terms of capabilities are so large that they overshadow the disadvantages.

Some of the major advantages in a computer system are as follows:—

1. Computers have a large capability for receiving, storing and manipulation of data. In one computer system, information representing millions of characters can be stored in one magnetic tape or disk which would otherwise require an enormous amount of paper and storage space under the manual system.

2. Computers process data in speeds ranging upto Nano second (one thousand millionth of a second). Consequently, a very big volume of data can be processed almost instantaneously. Such fantastic data processing speed has for example been made use of in steering space-crafts. In business application areas, these speeds have been used to develop real-time systems.

3. Complex mathematical calculations involving several variables can be handled by computer systems. These capabilities have been made use of in operations research techniques for solving complex business problems. This would never have been possible under the manual system.

4. Rapid access speeds of a computer facilitates quick data retrieval. This has been found useful in several busi-

ness applications For example in the banking industry a customer can present a cheque at any Branch of the Bank and the Bank's computer can give the status of his account as the computer is simultaneously connected to a central computer where this information is stored

The primary capabilities of computers can thus be summarised as below

1 Ability to handle vast volumes of data
2 Self operational ability
3 Ability to communicate effectively
4 Ability to take a decision on the basis of instructions
5 Ability to check the accuracy of its own work
6 Ability to do new tasks

Schematic Diagram of an Information System

A Schematic reprasentation of an Information Systam in a typical marketing organisation is givan in Figura 8 1

This total Information Systam is organisad into five groups or sub systems

1 Inventory
2 Financial
3 Production
4 Research and Oevelopment
5 Distribution and Sales

The information sub systems are all interconnected The interconnection is indicated by data flow lines which show also how data flows in and out of a system The main inputs to the system are the Sales Orders and Purchase Orders/Vendors Invoices The data contained in these inputs are processed by a computer and on the basis of the information generated management decisions are made as indicated by the data flow lines The various information generated is grouped under one information system which is the total system

The final output of the system is the supply of products to customers coming out from the distribution and sales information system

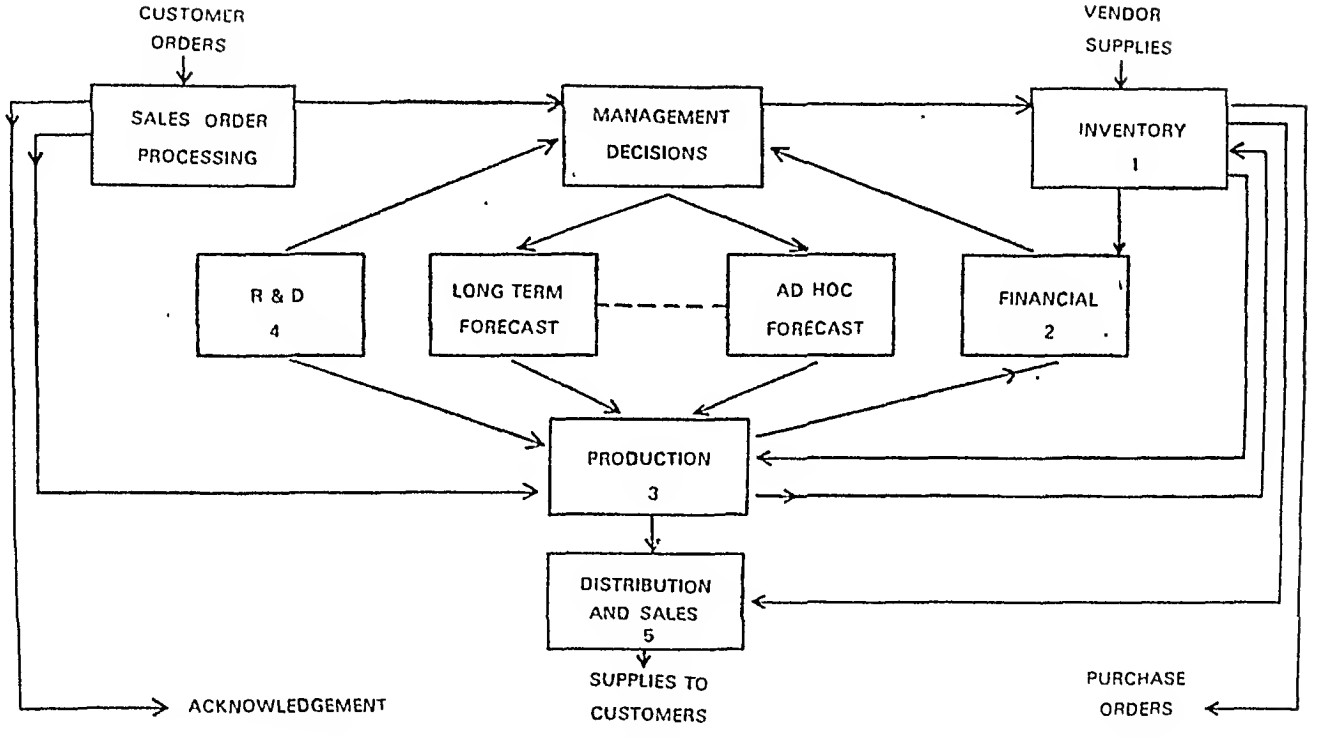


Figure 8.1. Schematic Diagram Showing Data Flow.

9. Unit Record Machines

The two most prevalent data processing systems in India today are

1 the Unit Record Machine system and
2 the Electronic Computer system

The Unit Record Machine system has become obsolete in the advanced countries mainly on account of the advances made in computer technology However in India today a large amount of data processing is still being carried out by the unit record machines Understanding the working of unit record machines is therefore necessary

Unit record concept

Since the beginning of this century the punched card (see Fig 9 1) has been used as a means of recording data for entry into a data processing equipment The basic principle of unit record data processing is that only one type of transaction is recorded on a single card For example if a sales invoice has ten different items recorded on it this would require ten different punched cards to record all the information Each of the cards would contain the information pertaining to a particular product and of course would contain all the basic data viz the customer's name and code number the sales area invoice number date and so on

Since each card contains information about a single type of transaction it is very easy to produce information from these cards in any manner one wants For example the statistics relating to the sales of one particular item can be

compiled by merely sorting all the cards relating to that particular item. Similarly, the sales to one particular customer or sales in a specific sales area or through a particular salesman can all be compiled easily by re-sorting the cards as desired. Every card, being an independent record, can be easily added or removed from a file or records. The unit record principle can be applied to any business situation where the isolation of individual transactions or grouping of similar transactions is required. The success of the punched card (see Fig. 9.1) in data processing arises from the fact that it overcomes three main problems in machine data processing:

(1) The first problem is that documents to be processed vary in size and shape. The card reduces them to a standard size in terms of dimensions and weight. This enables the machine to select the various cards containing the information and convey them through the machine one at a time.

(2) Secondly, there are variations in the methods used to enter data on documents. For example, some may be handwritten, others may be typewritten and others entered by other means, e.g., a Bradma machine. The punched card standardises this by having a punched hole as a means of entering data. These punched holes can be read mechanically or electronically to accomplish automatically the various steps in data processing. Once data is punched (recorded) on a card, it is a permanent record and it can be used over and over again for different purposes.

(3) The third problem is that various transactions are usually recorded on a single document. This will not be easy for a machine to understand. By having one punched card for one transaction, this problem is solved.

Data processing with a unit record machine system

Data is processed in a Unit Record system through four major machine operations in the following manner:—

(i) **Punching:** This is the recording of essential data on punched cards. The data can be in digits (1, 2, 3..... etc.) letters (a, b, c., etc.) or in characters ($, ?..... etc.). The punching of the holes on the card is done by a machine called the **Key punch.**

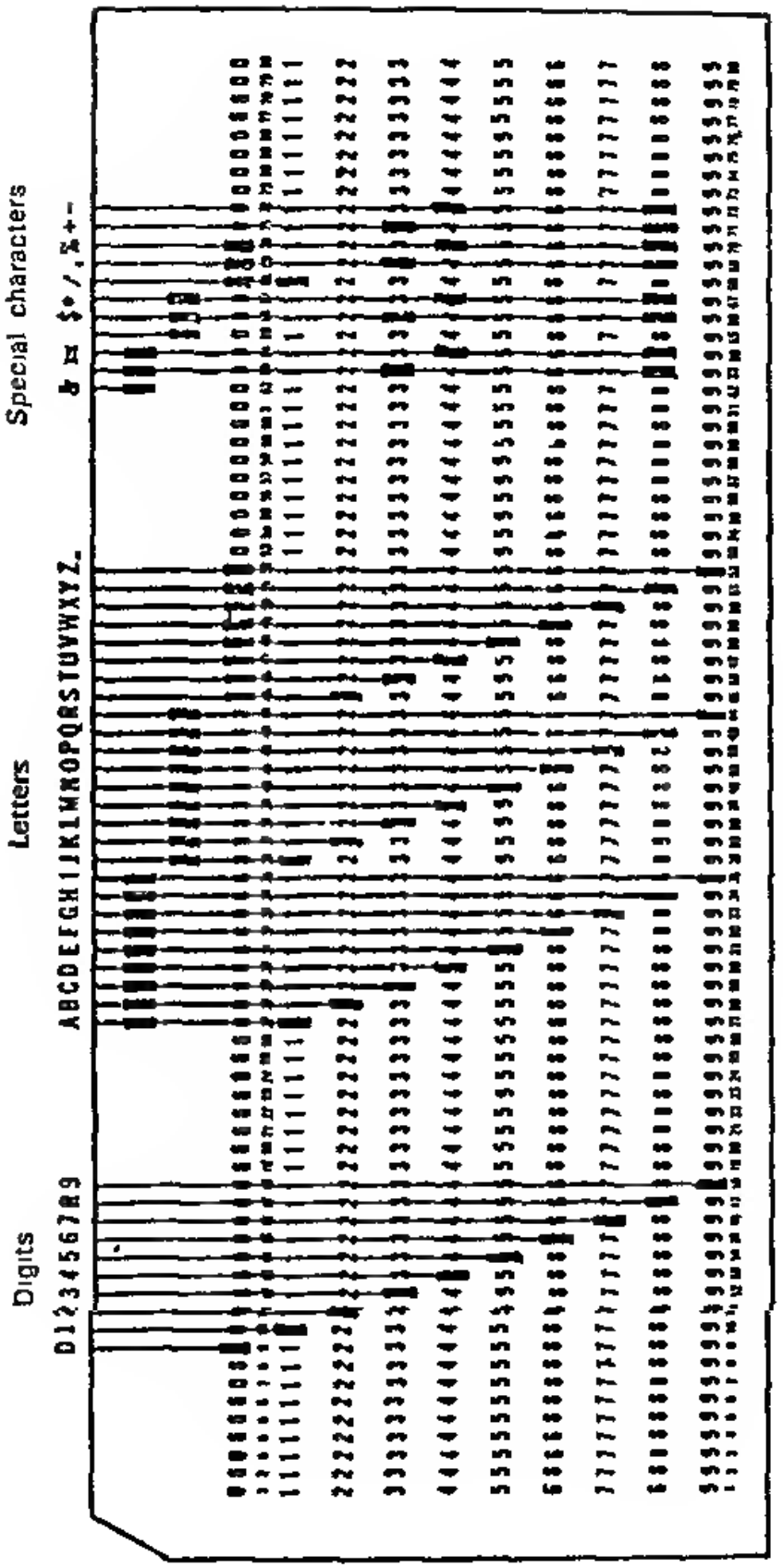


Fig 9 1 Punched Card

(ii) **Verifying:** After punching the data, on the cards, it is necessary to verify the accuracy of the data recorded. This checking of the punched cards is done by a machine called the **Verifier.**

(iii) **Sorting:** Punched cards have to be arranged in a logical sequence for the production of a particular input or output. The cards are sorted out and arranged in the desired sequence. This is done by the **Sorter.**

(iv) **Tabulating:** The sorted cards containing all the data required for the final output is placed in a machine called the **Tabulator.** This prints out the required report in the manner required. Tabulating also includes listing, calculating and recording of balances carried forward and brought forward, wherever these are appropriate, and final balances, as well as the accumulation of progressive totals and final totals. All these functions are done by the Tabulator.

The four basic tools for data recording, calculating and production of statistical reports in an office, e.g., the Punch, Verifier, Sorter and Tabulator are adequate to dispose of both rapidly and adequately a very wide variety of routine clerical and accounting tasks.

However, an Unit Record Machine (URM) installation may have other machines to aid, expedite or enlarge the scope of mechanised accounting, particularly to carry out certain arithmetical functions outside the orbit of normal Tabulator operations. Such machines are reproducers, collators, multipliers, interpreters, etc.

The details of the machines are given later in this chapter.

A typical machine configuration in an unit record installation would consist of:

Key Punchers	—	8
Verifiers	—	8
Sorters	—	2
Collator	—	1
Multiplier	—	1
Tabulator	—	1

The exact combination depends upon the actual work load on each machine The machines are selected on the basis of optimum cost benefit

Unit record machines are essentially electro-mechanical devices These equipments hava a wiring panel and a plug board panel They have a system very similar to a telephone key board to activate the equipment These machines pro cess data on the basis of arithmetic operations, like addition, multiplication etc and are much faster than the manual sys tem As a result they were found to be suitable for busi ness applications in areas such as financial accounting stores accounting, pay roll accounting, sales statistics etc It is only since the early seventies that some machines, like ICL 1004 Deta Processor and IBM 407 Accounting Machines have had electronic circuits and work on programmed ins tructions concept increasing tha capability of unit record machines

The sequence of operations are as follows —

1 The documents are batched according to the number of cards to be creeted A batch control slip is then mede out This control slip

* Identifies tha batch
* Identifies the documents
* Indicates the number of documents
* Indicates the batch control total

2 The cards are punched and verified The cards are tabulated and the batch control total is arrived at and com- pared with the control slip total

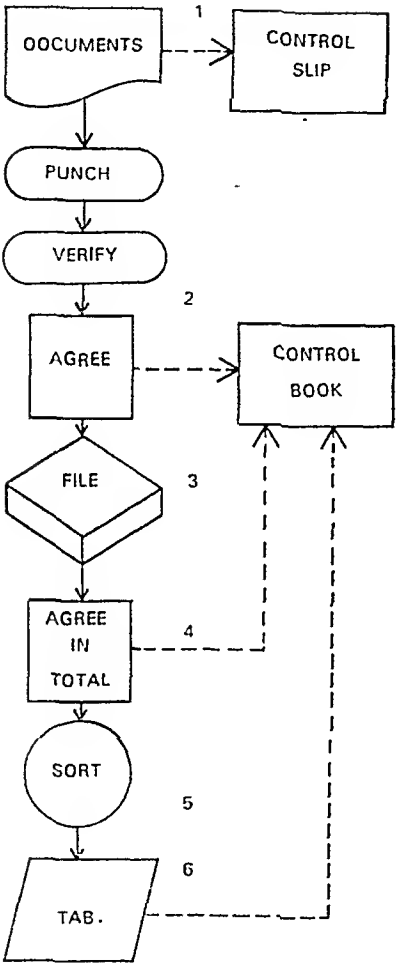
3 The cards are filed

4 At the end of the period all cards in the batches are added and the grand total is tabulated and checked with batch totals

5 Cards are sorted in the designed order

6 Sorted cards are tabulated Control totals are checked again

A flowchart of sequence of operations is given in Figure 9 2



1. Documents are batched according to the number of cards to be created. The Control Slip identifies the documents shows the number of documents and additive or gibberish totals.

2. Tabulate the punched/verified cards and agree to the control slip totals.
Enter the agreed total into the Control Book.

3. File the cards to await the end of the period.

4. At the end of the period tabulate all cards (ignoring batches) and agree their total to the summation of the batch totals in the Control Book.

5. Cards may then be stored into any desired order.

6. Tabulated to give an end product the total of which will be agreed with the Control Book total.

Figure 9.2. Sequence of operations in A URM

Comparison of Unit Record System with Computer System

Thanks to the rapid development of computer technology the unit record machines have outlived their usefulness Today a modern computer system offers far greater advantages compared to a unit record system for the same cost These advantages briefly are as follows —

1 The major disadvantage of a unit record system is that it has only one input media viz the punched card The punched card as a storage media is not convenient to handle in large numbers Modern computers make use of better input and storage media like magnetic tapes which have several advantages over punched cards The cost of storage of information gets drastically reduced with magnetic tapes

2 A unit record system does not have the flexibility that a computer system has Modern computer technology has made possible the simultaneous processing of more than one job

3 The arithmetical capability of a unit record machine is very limited

4 A unit record machine being a mechanical device is less reliable than a computer and requires constant maintenance

5 The biggest advantage of a computer is of course its power A computer is over a hundred times more powerful than the fastest unit record machine

6 Once the volume of data for processing goes above a particular level the unit record system becomes uneconomical to operate and proves costlier than a computer system

Having got a broad idea of the system we shall now go into some details of its working

Punched Cards

As stated earlier the purpose of punched cards is to enable the transfer of data in a machine readable form

Standard cards measure $7\frac{3}{8} \times 3\frac{1}{4}$ and are 0 0067 thick These cards must meet rigorous quality specifications in

order to assure accuracy of results and faultless functioning of machines which handle them.

To aid identification, cards are available in a number of colours. For example, in an inventory application, all the stores issue cards can be of green colour so that they are easily identifiable and do not get mixed up with the others. Similarly, the cards have one top corner cut and this enables the detection of any error in the way a card is kept, e.g., backward or upside down in the deck. Corner cuts also provide means of visually distinguishing two classes of data. For example, all sales transactions can be in cards with right corner cuts and all purchase transactions in left corner cuts.

The punched card has 80 vertical areas called card columns (see Fig. 9.1). These are numbered 1 to 80 from left to right. Each column is then divided into 12 punching positions called rows, and these punching positions are designated from the top to the bottom of the card. From Figure 9.1, you will notice that these are marked 0 to 9. Above the 0 row, are rows 11 and 12. Each column of the card is to accommodate a digit, a letter or a special character.

The top three punching positions of the card (12, 11 and 0) are called the zone punching positions while 0 to 9 positions are digit punching positions (0 is common to both).

For alphabets, a combination of zone punch and a digit punch are used as will be seen from figure 9.1. The combination of punches follows a simple pattern.

* First nine letters A to I — Combine 12 zone with digit punches 1 to 9.
* Second nine letters J to R — Combine 11 zone with digit punches 1 to 9.
* Third eight letters S to Z — Combine 0 zone punch with digit punches 2 to 9.

Eleven special characters are recorded by one, two or three punches in a column.

The most commonly used code for punching cards is the Hollerith code, which has been given in Figure 9.3.

Character	*Hollenth code* (Row number punched)
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	12—1
B	12—2
C	12—3
D	12—4
E	12—5
F	12—6
G	12—7
H	12—8
I	12—9
J	11—1
K	11—2
L	11—3
M	11—4
N	11—5
O	11—6
P	11—7
Q	11—8
R	11—9
S	0—2
T	0—3
V	0—4
U	0—5
W	0—6
X	0—7
Y	0—8
Z	0—9

Fig 9.3 Hollenth Code

You will notice from Figure 9.1 that the zone 11 and 12 punches are not printed as the other rows. This is intended for recording or printing any specific information needed by the user. In addition to colour or printed headings on the cards itself, another means of card identification and prevention of mix-up is by a control punch. This is done by a punch made in 11 zone on all cards belonging to the specific type. For example, take Issue and Receipt cards. Most of the data on the cards is of a similar nature, e.g., name of item, unit, quantity, date, etc. Because of this feature, the cards may get mixed up unless properly identified. This is achieved by the control punch.

The zone punches also serve to provide controls for certain operations and machine functions. In an 11 zone punch for example, a designed column of a card field may be used to identify the figure recorded there, as a negative item, i.e., one to be subtracted. The 11 and 12 zones also may be used (by relevant punches) to actuate special devices and machine functions. When used for purposes of machine control the 11 zone is known as "X" punch and the 12 zone is known as the "Y" punch.

The top edge of the card is called the "12-edge" and the bottom edge called the "9-edge".

Card design: Since one card represents one transaction, great care should be exercised in designing the card. In a punched card, there are 80 columns. Consequently, if the total characters required to be represented are more than 80, then obviously more than one card would be required to represent the entire details in a transaction.

The transaction is first broken down to various data elements. In a typical customer's accounting application, the data elements could be:

Customer's name
Identification number
Product name
Product code
Quantity
Unit price
Total price
Order reference
Date.

The columns of a card are divided into separate segments called fields consisting of one or more consecutive columns which are reserved for punching a specific type of data For example, each of the nine data elements listed above would be accompanied in a separate field

The maximum digits/letters required to represent each data element, i.e., the field length, is then decided This naturally depends upon the coding structure (See Chapter 10 on coding and classification)

For each data element a field in the card is allotted For example, the allocation of fields in this case could be:—

Title	Maximum digits/ Letters	Columns required	Columns Allotted
Customer's name	6 Digit Code	6	1— 6
Identification No	6 Digit Code	6	7—12
Order Reference	4 Digit Code	4	13—16
Product No	8 Digit Code	6	17—24
Product Code	8 Digit Code	8	25—33
Date of supply	4 Digit Code	4	34—37
Unit Price	6 Digit Code	6	38—43
Qty Supplied	6 Digit Code	6	44—49
Total Price	10 Digit Code	10	50—59

Since the data that is to be represented could be accommodated in 59 columns, there are still 21 columns that can be used In such cases, either—

1 blanks could be left between fields to make it possible for increasing the columns available for each field in the event the coding structure is enlarged, or

2 representing some more details, if necessary, in the unused columns, if the data base is to be widened

The fields of a card should be arranged in such a way that the data can be punched into the card in the same sequence in which it is read from the source documents Data should be read from left to right or top to bottom Similarly, in developing the card design, the final format of the output form has to be kept in mind It is always advisable to design the input form, card design and output formats simultaneously so that fields can be correctly sequenced.

The principle of alignment should also be kept in mind while designing a card, where a card is used with other types of cards for similar operations. The data item should generally occupy the same columns assigned to comparable data in other cards to which it is related.

Card Punch

The most common method of recording data on punched cards is by a manually operated machine, called a card punch. It is sometimes called a key punch as the machine has a keyboard almost similar to a typewriter keyboard. The operator reads the source document and depresses the relevant keys in the same manner as on a typewriter. The machine punches the holes on the card.

The machine feeds, positions and ejects cards automatically. The blank cards are kept in a card hopper and they are fed automatically into the machine and follow one after the other along the card bed. When column 80 of the first card passes the punching station, the second card gets automatically positioned in column 1 and another blank card falls into the card bed.

After punching, the card proceeds to the reading station where an important function is performed. Quite often some of the information in a group of cards is repetitive. Punching the same data over and over again in each card will be time-consuming. The task of punching such common data is performed automatically by depressing a "duplicate" Key. The machine senses the corresponding columns in the reading station and punches the same holes on the card at the punching station.

Similarly, certain repetitive operations can be accomplished automatically by means of a device called the program unit. A program card is prepared and this tells the machine what to do on each column as the card passes the punch dies.

After each card passes the reading station, it is fed into the card stacker located at the upper left hand of the machine. The stacker holds up to 500 cards in the same sequence as they are punched.

Card Verifier

It is vital that all the data punched on a card is hundred percent accurate Since this is the basic input any mis take here can cause inaccuracies down the line and of course in the final output The information on the card has there fore to be checked for accuracy This is done by a card verifier This machine is almost the same as the card punch and is operated almost in the same manner on a keyboard with the operator using the same source docu ment and following the same sequence The same punched cards are fed along the machine As the relevant key is punched the machine senses the hole already punched and if the punching is correct the card moves on to the next column If the operator has depressed a wrong key or if the original punching is wrong the machine locks and signals an error The Oparator can once again verify If the mis take is in the onginal punching the card has to be punched once agein If the card has been punched correctly a notch is made on the right edge of the card opposite the 1 row

Reproducer or automatic punch

Thia machine is a high speed automatic punch end is used for reproducing punched alphabetical and numencal data from one set of cards to another The reproducer performs three separate and distinct functions—

(a) Reproduces part or the whole data recorded on one set of cards on to another set of cards in one operation The need for this anses in several applications where the data is common from period to period with change in only one or two data elements

(i) It does gang punching which means punching repe titive data from a single Master Card Say for example a particular regional code is to be punched in a set of cards This machine can punch this code into several cards auto matically

(c) Compares data recorded in punched hole form

(i) as between two sets of cards and

(ii) in succeeding cards

These functions are reproduction gang punching and comparison may be carried out simultaneously

Sorter

Following the punching of the cards and their verification, they must be arranged in the proper sequence to facilitate further processing. Further, after the initial arrangement, say, the sales data for a month productwise, they might have to be rearranged in various ways for preparing special reports, say, productwise for the whole year. These functions are performed on a machine called a sorter.

One of the main advantages of a punched card is that they can be arranged in sequence according to the specific field on the card. The field that is selected is called the "Control field". Say, we want figures productwise and there are a hundred products. The cards can be sorted out in terms of the product code field. Manual sorting in this manner would take a long time. The sorter does this automatically and at very fast speeds upto 750 cards per minute.

The operations that a sorter can perform can be categorised into the following four:—

1. **Numeric sorting:** Cards can be arranged in numerical sequence by sorting all columns of the control field one at a time, proceeding from left to right. The machine has ten sorter pockets. The cards are then replaced in the machine and the sorting is done on the second (or tens) column. This can be repeated till the entire field is completed.

2. **Alphabetic sorting:** In this case cards have to be passed through the machine twice for each column has two punches. (Zone punch and digit punch).

5. **Digit sorting or selecting:** It may often happen that we do not want all the cards but only cards pertaining to one specific item. Selection switches provide a means of selecting certain items that require special attention without disturbing the sequence of the other cards on the file. Thus, we may sort out all cards pertaining to steel from a whole lot of cards containing all items of inventory. This can be done without affecting the remainder of the file.

Collator

There are several complex card arrangement and handling functions which the sorter cannot achieve. These func-

tions are performed by the collator, which supplements the work of the sorter

The basic function of the collator is to feed and compare two files of cards Simultaneously in order to match them or to combine the two files into a single file At the same time the collator will automatically detect and separate cards from each file which do not have a matching card in the other file

A collator can perform the following functions at high speeds

(i) Sequence checking After the sorter has compiled a file of cards in a particular sequence the file can be checked on a collator to determine if the sequence is correct The collator does this by comparing each card with the one ahead of it The machine will either stop if an error is detected or if so desired it will separate all the cards out of sequence

(ii) Merging Two files of cards already in sequence can be combined (or merged) to form one single file The two files are fed simultaneously into the machine and the cards are merged in the desired sequence

(iii) Matching In this case instead of merging two files cards of either file that do not match the other are separated and the cards that match remain in the original two groups

(iv) Merging with selection If any of the two files contain cards which do not match with the cards in the other these cards can be separated The machine will deposit them into a separate pocket Those that match will be merged

(v) Card selection The collator also has the ability to select certain types of cards from a file without disturbing the sequence of the others

The programme of processing the cards is in accordance with instructions drawn from control panels These panels can be quickly interchanged

Tabulator

This machine processes data contained in punched cards and presents the results in the form of printed lists and

summaries. Punched cards are read and data entered into the machine through the input mechanism which has two consecutive sensing stations. Information is processed and printed from punched cards on the basis of instructions drawn from the control panel which is plugged in. The machine has counters where data can be accumulated. It makes possible the building up of minor, intermediate and major totals. While these totals are automatically printed, the final totals can be controlled by the Operator.

Tabulators also have the facility for automatic feed of continuous stationery. These machnes have a speed of 100 cards a minute.

Program card punch

Several advanced data processing machines are now available with increased capabilities. The major advantage is faster and more accurate processing with lesser human intervention. A Program Card Punch facilitates—

* automatic skipping of cards
* gang-punching
* spacing over remaining columns of an alphabetic field.
* programmed or key selected punching of constant information.

Program Card Verifier

Similarly, a Program Card Verifier also facilitates gang verification and programmed or key selected verification of constant information.

ICL 1004 Data Processor

The capabilities of an unit record machine can be best illustrated by describing in detail one of the advanced machines in use. Since IBM is no longer in the Indian market, it is proposed to describe the I.C.L. 1004 data processor. In this data processor, the cards are fed and output lines are printed at speeds upto 400 a minute. Punched paper tape input and output can also be incorporated into the system. Cards are read by photo electric means. The Tabulator has 961 locations each, with a capacity of one (six bit) charac-

ter The printer has a width of 132 positions, each of which has a set of 63 alphabetical numericel and symbolic characters Stationery from 4 to 22 inches wide upto six copies can be fed in a single, multiple or long throw spacing (leaving a larger gap between lines) under the control of the program and a punched loop The basic cycle time of the ICL 1004 is 8 micro seconds and this gives the following arithmetical speed

Compare	two 6 digit fields	0 123 milli seconds
Add	two 8 digit fields	0 160 milli seconds
Multiply	6 digit field by a 4 digit field	4 576 milli seconds average
Divide	a 6 digit field by a 4 digit field to obtain a 5 digit quotient	6 704 milli seconds average

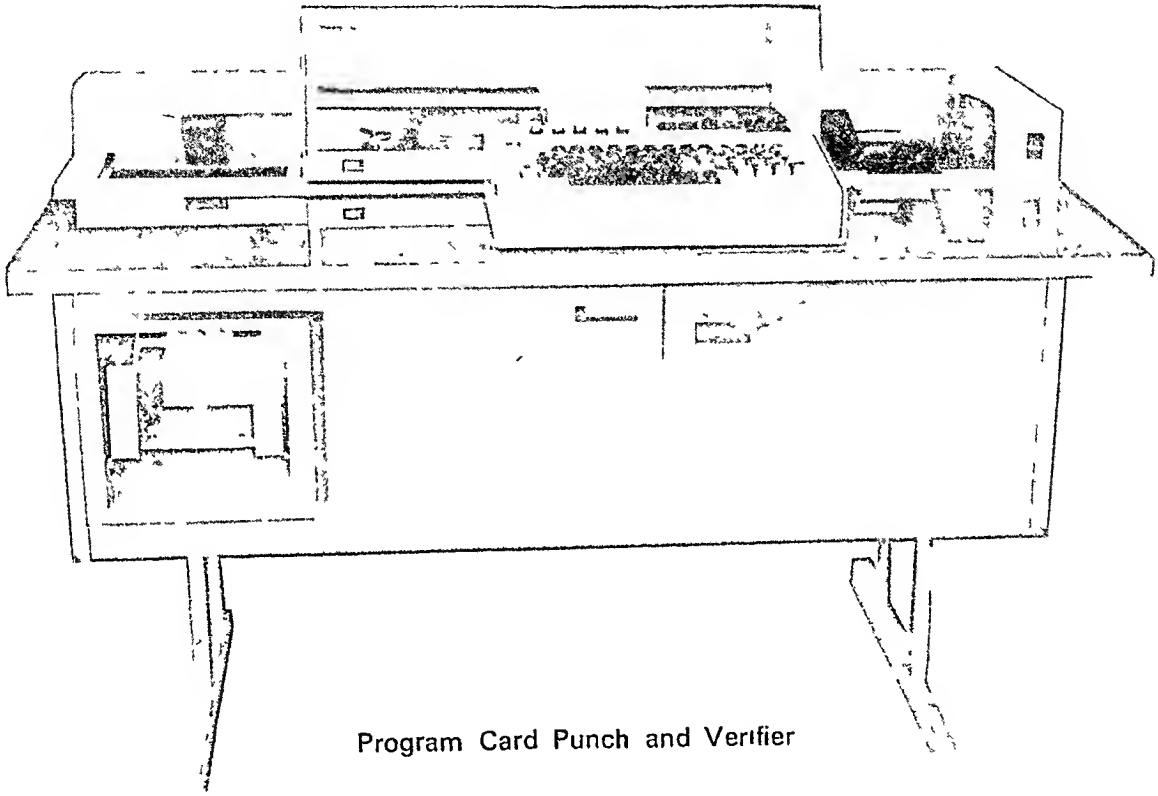
A punched card output punch with a speed of 240 cards a minute can also ba attached to this machine

Tha card reading speeds are as follows

Machine Speed — 400 cards a minute under program control

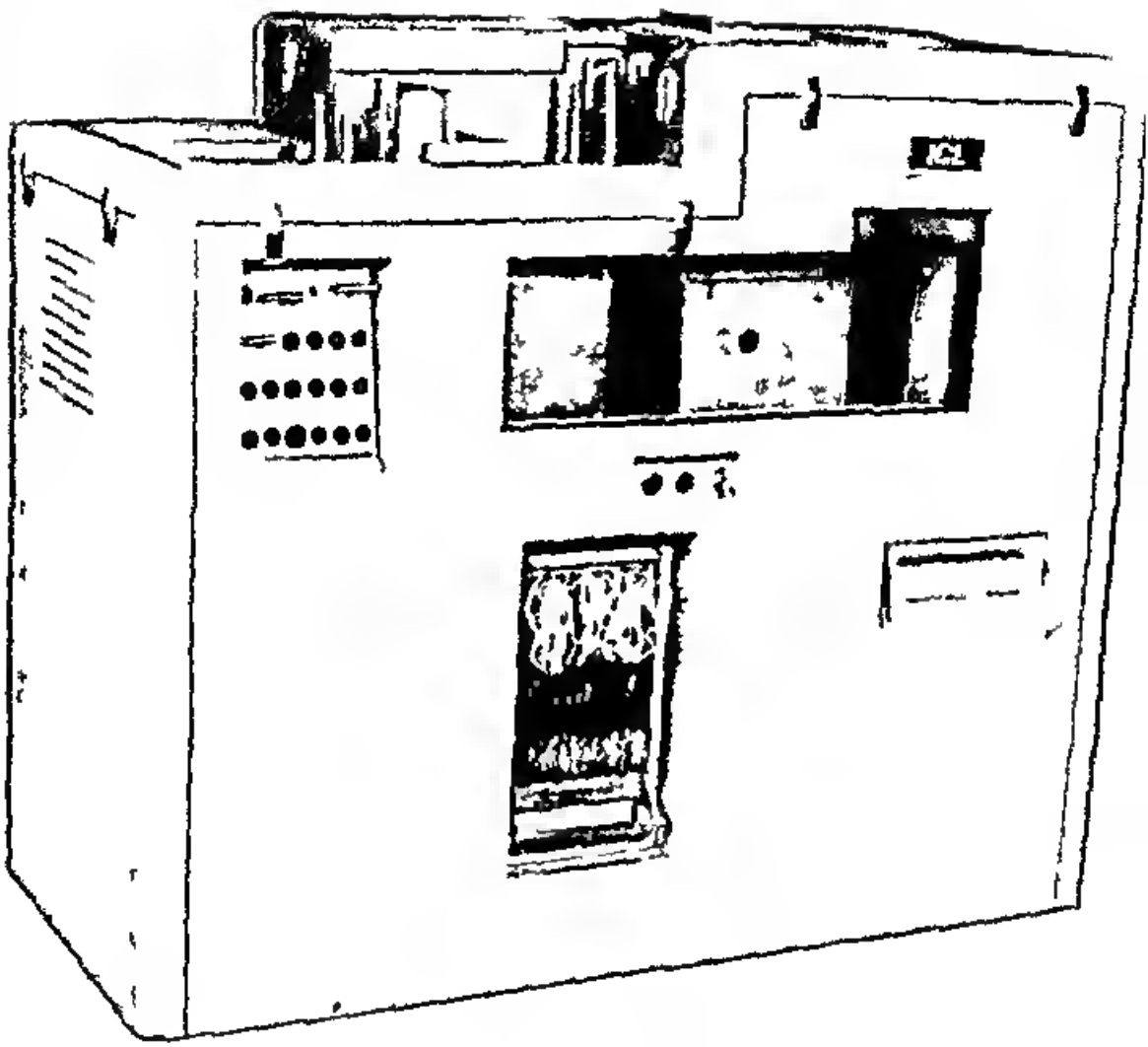
Reading time — 61 00 milli seconds for first column and 1 32 milli seconds for each succeading column

These machines have a cycle tima of 8 micro seconds Provision exists for reserving storage areas for reading printing and punching data In addition 961 core storage positions can be added



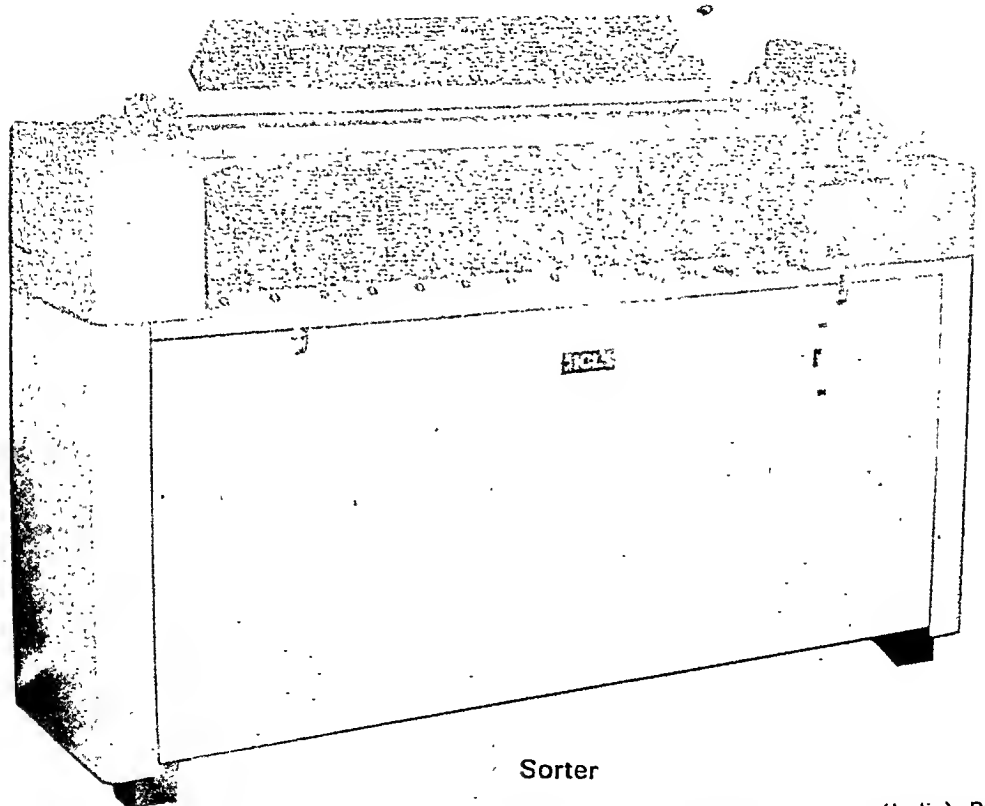
Program Card Punch and Verifier

Courtesy . International Computers (India) Pvt Ltd Bombay



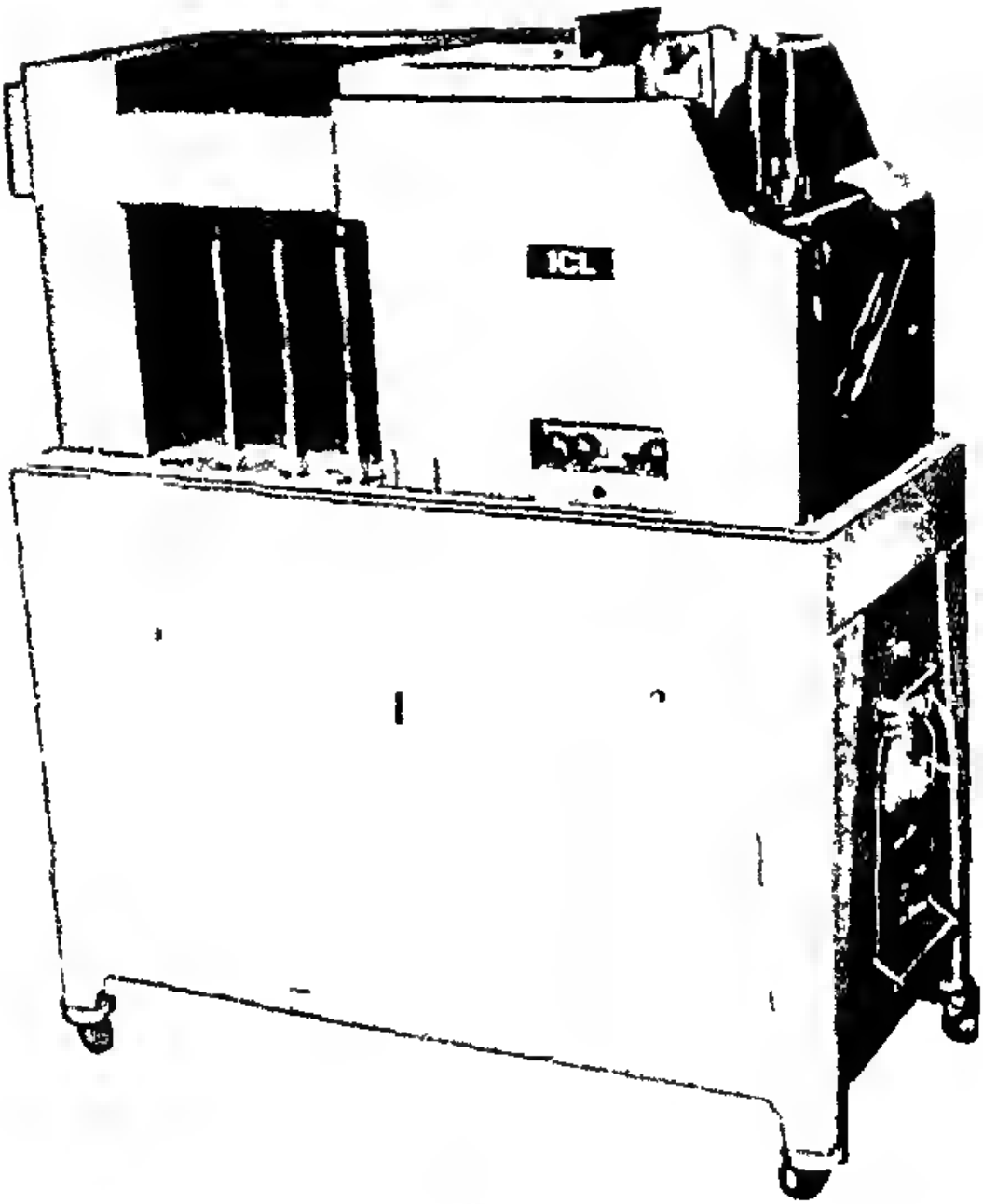
Reproducer

Courtesy International Computers (India) Pvt Ltd Bombay



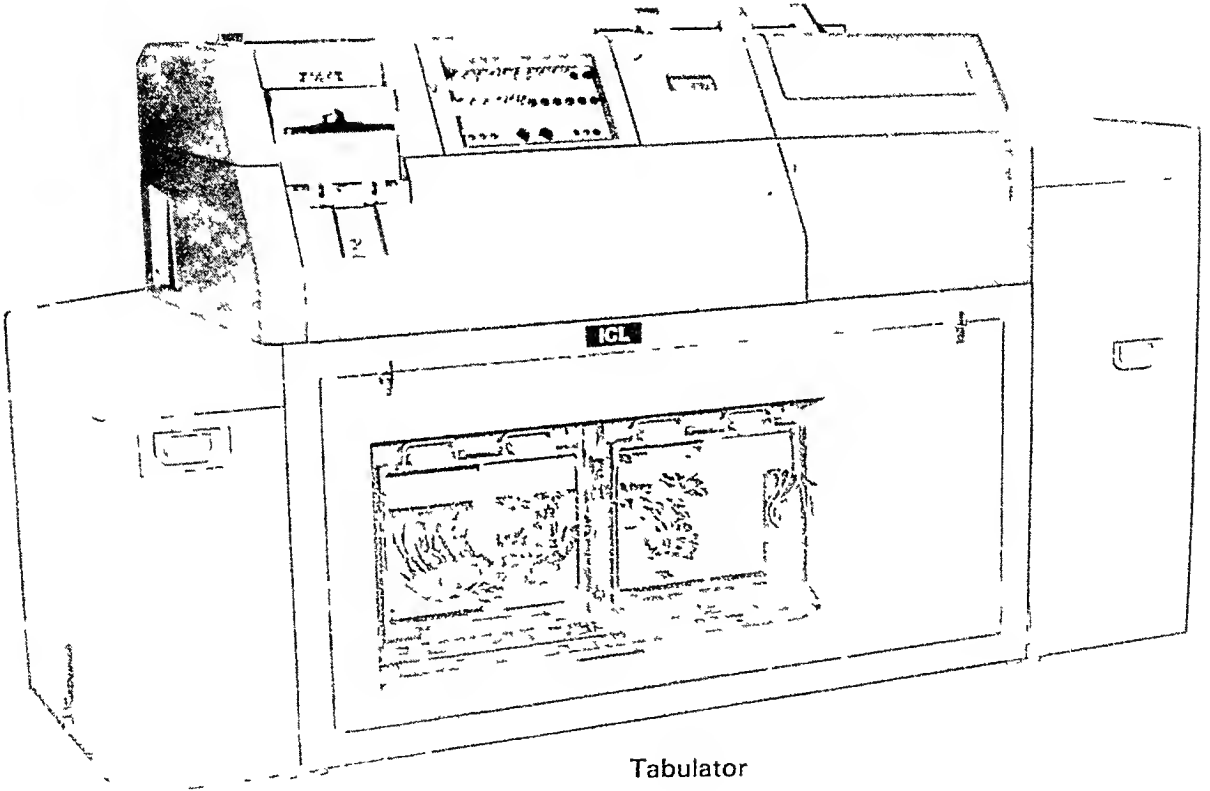
Sorter

Courtesy : International Computers (India) Pvt. Ltd. Bombay.



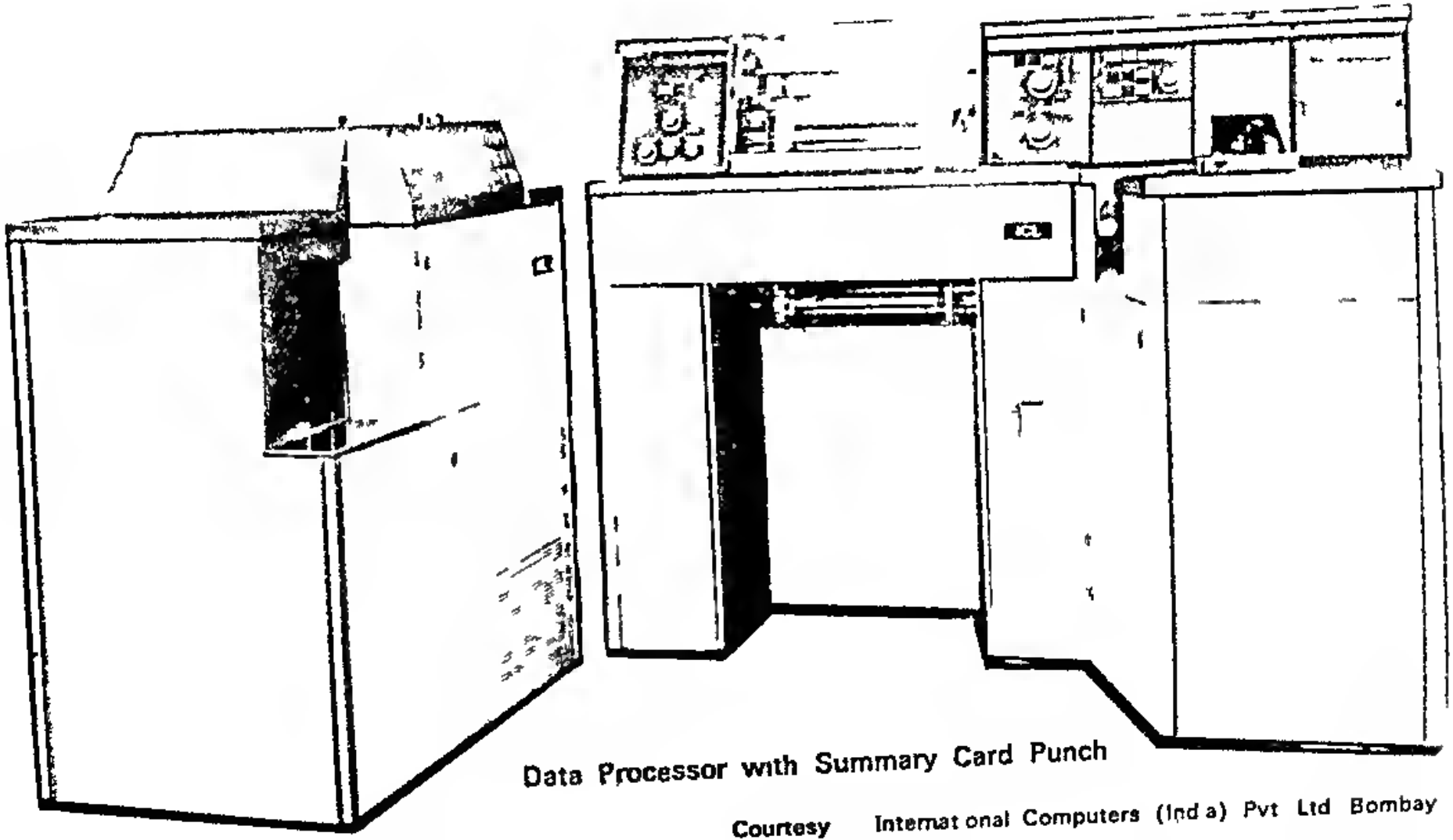
Collator

Courtesy International Computers (Ind a) Pvt Ltd Bombay



Tabulator

Courtesy International Computers (India) Pvt Ltd Bombay



Data Processor with Summary Card Punch

Courtesy International Computers (India) Pvt Ltd Bombay

10. Coding and Classification

For processing in a computer, all data should be coded either in digits or a combination of digits and characters. The determination of the coding structure is of vital importance and needs to be carefully done. However, there are certain basic principles to be kept in view before finally deciding upon a coding structure.

1. Before deciding on a coding scheme, system analysis should be completed to determine the information requirements.

2. The data items involved should be studied in detail with a view to understanding their special characteristics.

3. A coding scheme can have various digits. For example, the Kodak System for inventories has 10 digits 3-4-3. There may be 3, 4, 6 or 8 digits in a code depending upon actual requirements. The number of digits in a coding scheme should permit not only the coding of all possible existing data items but should also cater to the requirements of the future.

4. The coding should facilitate the fast processing of data by computer.

5. The position of each digit or character should represent a particular characteristic, e.g., the first two digits might represent the sales area, the third and fourth the product, etc.

6. The coding should be developed in a logical manner and should facilitate the development of new codes.

7 The coding must take into account future requirements and should not get invalidated in a short time

8 The coding should be simple and as small as possible In other words, if a given purpose can be served by the use of lesser digits that should be preferred More number of digits would mean greater storage requirement or more sorting and access time Hyphen decimal points commas etc should be avoided in a code

9 The coding should be free from ambiguity No item should be capable of being coded under two categories

10 A code number is much shorter than a long description A three digit code can identify 1 000 items whereas using letters may normally require 8 letters

11 Where common data items are used in different applications the codes should be the same For example Customer Account Code should be same both for debtors accounting and sales analysis or the product code should be the same for production or sales

Before a coding system is finalised it is necessary for the Systems Analyst to consult both the user department as well as Programme staff The user department must fully understand the significance of the coding system and should normally control the allotment of new codes

From the programming side the coding should be studied in depth so that there is no waste of time at the time of sorting In many cases improper coding might result in having to punch two cards for recording a particular data item resulting in increase in cost of stationery and computer processing time

The most common method of coding adopted in a business organisation is the block code where blocks of numbers are allotted to a data item For example in Financial Accounting application a coding structure could be developed using block codes in the manner given below

Assets	100 to 300
Liabilities	301 to 500
Income	501 to 700
Expenditure	701 to 999

Within the block the various types of items may be allotted different codes by dividing this again into logical groups under specific characteristics within the group. For example, under Assets, such grouping can be:

Fixed Assets	100 to 200
Investments	201 to 250
Current Assets	251 to 300

This can be further sub-divided, as for example:
Fixed Assets:

Land	100 to 110
Buildings	110 to 120
Plant & Machinery	121 to 150
Furniture & Fixtures	151 to 200

Such sub-divisions can continue further as required.

Another method of coding is to make each digit represent a specific characteristic. For example, the classification of financial items could be as follows:

1st digit to represent:

Assets	1
Liabilities	2
Income	3
Expenditure	4

2nd digit to represent:

Fixed asset	1
Current Asset	2
Investment	3

3rd digit would represent major grouping, say, current assets:

Cash	1
Stocks	2
Debtors	3
Stores	4

4th digit may represent, say, for debtors:

Services	1
Product supplies	2

Thus a code number 1 2 3 2 would convey that it is—
1. Asset, 2. Current Asset, 3. Debtor, 2. Product supplies.

It will be quite apparent that for information retrieval this offers great flexibility However under this system there is likely to be a larger number of digit positions than the system described earlier

Mnemonic codes

The word Mnemonic means assisting the memory Where therefore it is necessary for the codes to convey a meaning quickly to the user mnemonic codas are used This is nothing more than a combination of alphabets and numbers e g RDB 462 where RD may stand for Retail Dealer B for Bombay and 462 the dealer a code number The alphabets ara used primanly to assist quicker under standing and not in the manner of tha numerical coding ays tem explained earlier

A good coding system is a pre requisita for an effi cient data processing system The simpler it is the better for it ia mostly clarks who make use of it and tha ease with which they can usa it will make for the efficiency of the syatem It is not only necessary to have a good coding aystem but it must be ensured that those who use it are fully familiar with it and use it correctly all tha time A wrong coding can ruin an entire programme

11. Data Representation

When we communicate we use symbols. In the written English language, for example, we use the 26 alphabets (in capitals and in lower case), ten numbers from 0 to 9 and a large number of special symbols like comma, full stop, question mark, the Rs. sign, etc. The computer, similarly, has its own language and uses symbols just as human beings do. There are approximately 100 symbols which are used in computer applications. The entire set of such symbols is often referred to as alphanumeric characters. In order to understand the working of computers, therefore, it is necessary to know how the computer handles data and how human beings can communicate with computers and vice versa.

We saw in Chapter 5 that computer storage consists of elementary devices such as magnetic cores. Each device recognises two states—an "on" or "off" position, i.e., one where the current is flowing and the other where it is not flowing. This is represented by the digits 0 and 1. These are called binary digits or bits. Every alphanumeric character is coded using unique combination of binary digits. All computations (arithmetic operations) are also performed by using the binary numbering system. One of the pre-requisites for understanding the capabilities and limitatons of digital computers is to understand the Binary System of data representation.

Binary system

We are all aware of how the decimal numbering system works From right to left, it represents units, tens hundreds, thousands and so on This can be represented as 10^0, 10^1, 10^2, 10^3, 10^4, 10^5 For example, 5324 could be regarded as—

Five thousands+three hundreds+two tens+four

In mathematical notation it can be written as—

$$5324=(5\times10^3)+(3\times10^2)+(2\times10^1)+(4\times10^0)$$

The binary system is similar to this system except for the fact that whereas in decimal system the positional values are powers of 10, in the binary system the positional values have powers of two i e 2^0, 2^1, 2^2, 2^3, 2^4, 2^5 or the equivalent of 1, 2 4, 8, 16 32 in the decimal system In a binary system only two digits viz 0 and 1, are used

The symbol 1 indicates that a particular power of two is present and the symbol 0 indicates that it is absent Hence, the binary number 101101 can ba regardad as—

$$(1\times2^5)+(0\times2^4)+(1\times2^3)+(1\times2^2)+(0\times2^1)+(1\times2^0)$$
$$=(1\times32)+(0\times16)+(1\times8)+(1\times4)+(0\times2)+(1\times1)$$
$$=45$$

In other words the binary number 101101 has the decimal equivalent of 45

The binary code is particularly useful for electronic storage and manipulation since it involves only 2 states and can be easily represented by an electronic switch being on or off, the direction of an electric current, or the state of magnetisation of a magnetic material

Data codes

In the above discussion we said how numerical information can be fed into the computer The two-state devices such as magnetic cores, can represent binary digits, and a combination of binary digits can in turn represent numbers in computer storage

However, the computer has to use non numeric information such as the alphabets and special characters To

represent this, various codes are used in the computer. For example, we saw in Chapter 9 the use of the Hollerith code for representing data. Some other codes used in data processing are discussed here.

Binary Coded Decimal (BCD)

To represent the digits 0 to 9 in a binary system, we must have a minimum of four binary positions. For example,

0 0 0 0 = 0
0 0 0 1 = 1
0 0 1 0 = 2
. . . . . .
1 0 0 0 = 8
1 0 0 1 = 9

In the BCD system, the first four binary positions are used to represent a decimal digit. It uses a 4-bit set to represent a digit in a number. For example,

0100	1001	0010	
4	9	2	= 492

It will be seen that since there are only 4 bits, the maximum number of characters that can be represented is $2^4=16$. This obviously cannot be used for representing all the alphabets and special characters. In order to make this possible, the BCD code is often extended to six bit positions. This extended code is called standard binary coded decimal interchange code or simply standard BCD.

The fourth and fifth positions are called zone bits and the first four positions, numeric bits. To represent a digit, the zone positions are set to zero. Alphabets and special characters are represented by combinations of zone and numeric bits. For example,

A = 110001
B = 110010
$ = 101011

In the standard BCD code the seventh position is also used This has no significance for representing alphabets but it is used for checking the validity of data and is called parity bit

EBCDIC (Extended Binary Coded Decimal Interchange Code)

In the stanterd BCD Code we use 6 bit positions for representing a cheracter In other words the number of combinations possible is $2^6=64$ i e , only a maximum of 64 characters (digits alphabets and special characters) can be represented under this coding system

Third generation computers often use additional charac ters numbering up to a hundred It is possible to represent these characters only if the number of bit positions is in creased For this reason the EBCDIC system has been devised for use in third generation computers In this sys tem ell characters are represented using eight bit positions plus e check bit The eight bit positions ere divided into zone positions (four bits) and numeric position (four bits) as shown below

Check bit	Zone Position	Numeric Position
C	Z Z Z Z	8 4 2 1

The enlargement of the bit positions from 6 to 8 per mits 2^8 or 256 character representations in the E8CDIC code

The EBCDIC code is illustrated in Figure 11 1

In computers using the EBCDIC code the eight bit posi tions are handled as one unit and is celled a byte A byte is equivalent to an eight bit character in the EBCDIC code and is the smallest addressable unit of information in such computers In other words a byte can represent a digit or an alphabet or a special character If a word has three letters then three bytes are required to represent it

A punched card as we have seen, has its own code This has to be converted to binary code to enable a com

puter to read the card. The conversion of punched card code to the EBCDIC code is carried out by the code translator which is an integral part of a computer. This conversion is not necessary when magnetic tape or punched tape is used. This is because the data is recorded in magnetic tape in binary code.

Parity bit

During the transfer of data in the computer, there is always a possibility of a digit being wrongly carried. To prevent this, in addition to the 8 bits, every word is provided with an extra bit, called a check bit or parity bit. The mechanism works in the following way. For example, the letter T is represented by 11100011. There are five 1 bits. The object is that the total of all the 1 bits should always be odd. The parity bit is to produce the total to an odd number always. In this case, since the total is an odd number, the extra bit will have 0. Next, let us take the word E which is represented by 11000101. The total of the 1 bits is four. The parity bit will have 1 and this, therefore, changes the total to 5, which is an odd number. When data is transferred from one storage location to another, the computer will check to see that the total number of 1 bits is odd. If one bit has been missed or an extra one added, the total will give an even number and the parity error condi-

DIGITS	Punch in	LETTERS	Punch in	SPECIAL CHARACTERS	Punch in
0	0	A	12 – 1	&	12 – 8 – 2
1	1	B	12 – 2	-	12 – 8 – 3
2	2	C	12 – 3	<	12 – 8 – 4
3	3	D	12 – 4	(	12 – 8 – 5
4	4	E	12 – 5	+	12 – 8 – 6
5	5	F	12 – 6	|	12 – 8 – 7
6	6	G	12 – 7	&	12
7	7	H	12 – 8	!	11 – 8 – 2
8	8	I	12 – 9	$	11 – 8 – 3
9	9	J	11 – 1	*	11 – 8 – 4
		K	11 – 2	)	11 – 8 – 5
		L	11 – 3	;	11 – 8 – 6
		M	11 – 4	¬	11 – 8 – 7
		N	11 – 5	—	11
		O	11 – 6	/	0 – 1
		P	11 – 7	∧	12 – 11
		Q	11 – 8	'	0 – 8 – 3
		R	11 – 9	%	0 – 8 – 4
		S	0 – 2	–	0 – 8 – 5
		T	0 – 3	>	0 – 8 – 6
		U	0 – 4	?	0 – 8 – 7
		V	0 – 5	:	– 8 – 2
		W	0 – 6	#	– 8 – 3
		X	0 – 7	@	– 8 – 4
		Y	0 – 8	¢	– 8 – 5
		Z	0 – 9	≤	– 8 – 6
				"	– 8 – 7
				Blank	No punch

Fig 11 1 Card Code (Corresponds to EBCDI Code)

12. Computer System Components —Basic Features

Computers are of two types—a special purpose computer or a general purpose computer. A special purpose computer is designed to solve a specific type or class of problems, as for example, a computer meant for use in a ship or aircraft to solve navigational problems, or for use for a special purpose in the Armed Forces. Other examples of this type are computers used for process control in chemical or petroleum industries, steel processing, power generation or for automated manufacturing processes.

General purpose computers are designed to provide solutions to various types of problems. A computer acts on the basis of instructions and can theoretically handle any problem which can be solved by computation. There are of course limitations imposed by memory size, speed and type of input and output. The versatility of modern general purpose computers makes it possible to use them for a wide variety of tasks like banking, sales analyses, cost accounting, supply and distribution, production scheduling, inventory control, etc.

Electronic computers are basically of two types—analog and digital, according to the manner in which they represent data.

An Analog computer sets up physical situations analogous to mathematical situations. It operates on data in the form of continuously variable physical quantities such as

pressure temperature revolutions speed voltage etc It is therefore essentially a measuring device

A digital computer which is the most common computer operates on representations of real numbers or the characters coded numerically It has a memory and solves problems by counting precisely, adding subtracting dividing and comparing This computer is best suited for business applications In this book we shall be talking only of digital computers

There is also a third type of computer called the hybrid computer which combines analog and digital capabilities Primarily the computer computes which is its basic function Other basic functions are that it stores data controls and communicates These capabilities enable electronic computers to process data in the following manner

1 The data to be processed and the instructions as to how the data is to be processed are recorded in an input medium e g a punched card punched paper tape magnetic tape etc

2 The data and instructions are fed into an input device where they are automatically converted into electrical impulses and routed to the main storage or memory where they are held until needed

3 The Control Unit obeys the instructions and directs the various data processing operations by issuing specific commands to the various components of the system

4 In accordance with the instructions the data is transferred from storage to the arithmetic/logic unit of the computer where the arithmetical operations or comparisons are performed according to the directions of the Control Unit

5 The data which has been processed is routed to the storage unit where it may be held for further processing or moved to an output device again as per the directions of the Control Unit

6 The data which comes out from storage is recorded by an output device in a medium such as punched cards punched tape or a printed document

This is illustrated in Figure 12 1

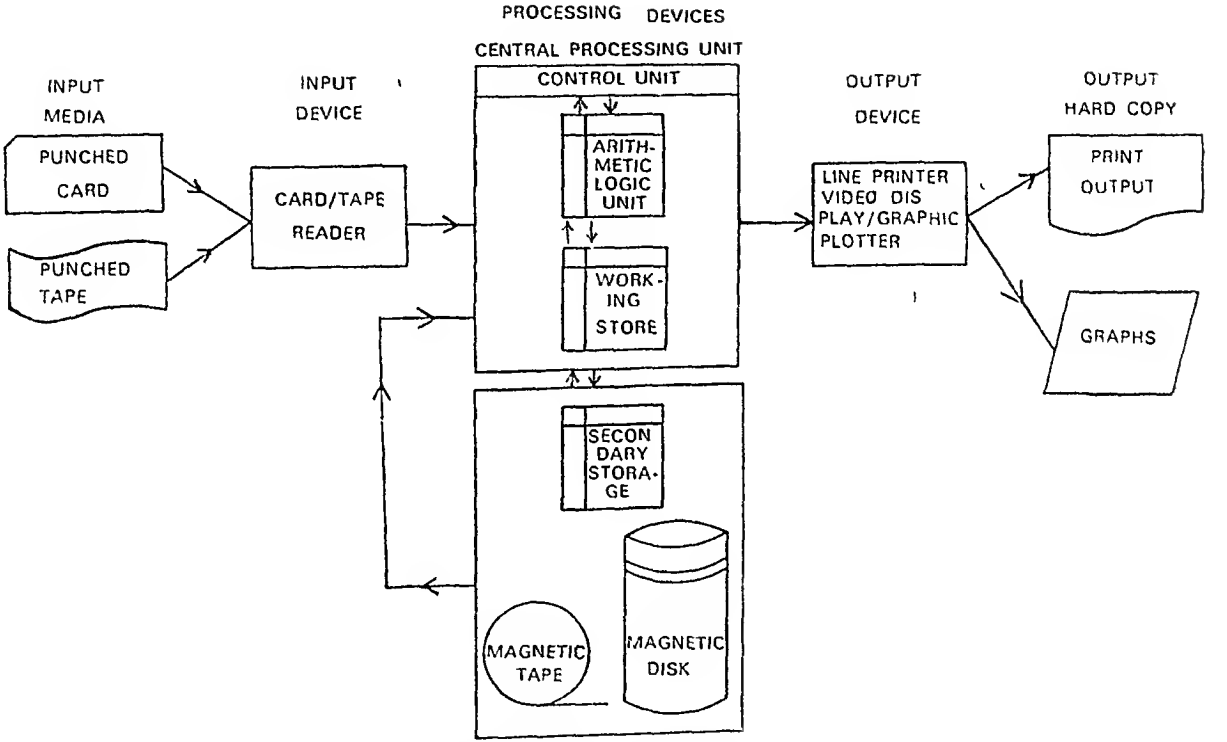


Figure 12.1 Computer system functional units

A comparison of three data processing systems is given below

Manual	URM	Computer
Data is sensed by the man through sensa organs like eyes and ears In the case of blind men data is sensed through touch	Date is coded and transmitted first into punched card	Date is fed into the computer through the mechanism of punched card and magnetic tapes Modem input devices can read data directly through special devices
Data is processed immediately if the quantum of data is small and processing is not complex otherwise date is recorded again on paper and processed in stages till the final result is obtained	Punched cards are sorted in a sorter The sorted cards are then fed as and when required into a tabulator which prints the output	The data is processed in the Central Processing Unit The processed information is kept in store and printed by means of fast printers as and when required

A brief description of the computer components is given below

The British Standard definition of a computer is "Any device capable of accepting data automatically, applying a sequence of processes to the data and supplying the result of these processes'

Computer Hardware

The hardware is a term applied to the mechanical, electrical and electronic features of a computer The term software relates to the programmes, procedures, routines associated with the computer in order to facilitate its use

The components of a computer are the Central Processing Unit and the peripheral equipment The term "peripheral" relates to the input and output devices of a computer

Input devices In order to process any data in a computer, data has to be fed into a computer first This data is

termed as "input" and the equipments which enable data to be fed in are called "input devices". These devices are—

Card Reader — When the input medium is punched cards.

Paper Tape Reader — When it is paper tape.

Magnetic Tape Unit — When it is magnetic tape.

Magnetic Disk Unit — When it is magnetic disk.

These equipments are described in greater detail in Chapter 13.

Central Processing Unit

After the computer has received the input, it processes the data in the Central Processing Unit (CPU). This is done in accordance with the set of instructions (programs).

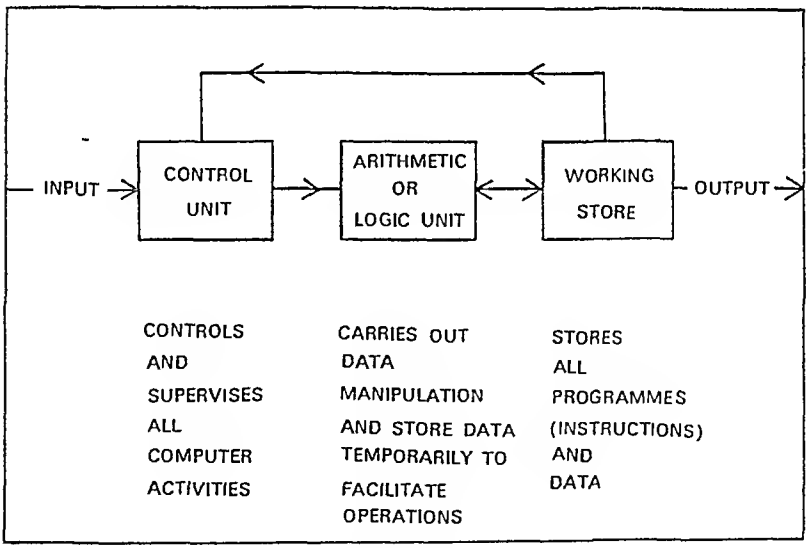

INPUT
CONTROL UNIT
ARITHMETIC OR LOGIC UNIT
WORKING STORE
OUTPUT
CONTROLS AND SUPERVISES ALL COMPUTER ACTIVITIES
CARRIES OUT DATA MANIPULATION AND STORE DATA TEMPORARILY TO FACILITATE OPERATIONS
STORES ALL PROGRAMMES (INSTRUCTIONS) AND DATA

Figure 12.2 Central processing unit

The job of the Central Processing Unit is to receive the data and store them at the assigned place and subsequently process them according to the instructions (programs) given and either store the output or cause it to be transcribed into

the output device The Central Processing Unit can also store all or some of the instructions Where this is possible the computer is known as a Stored Programme Computer

There are three main parts of the Central Processing Unit

1 Working Store,
2 Control Unit and
3 Arithmetic/Logic Unit

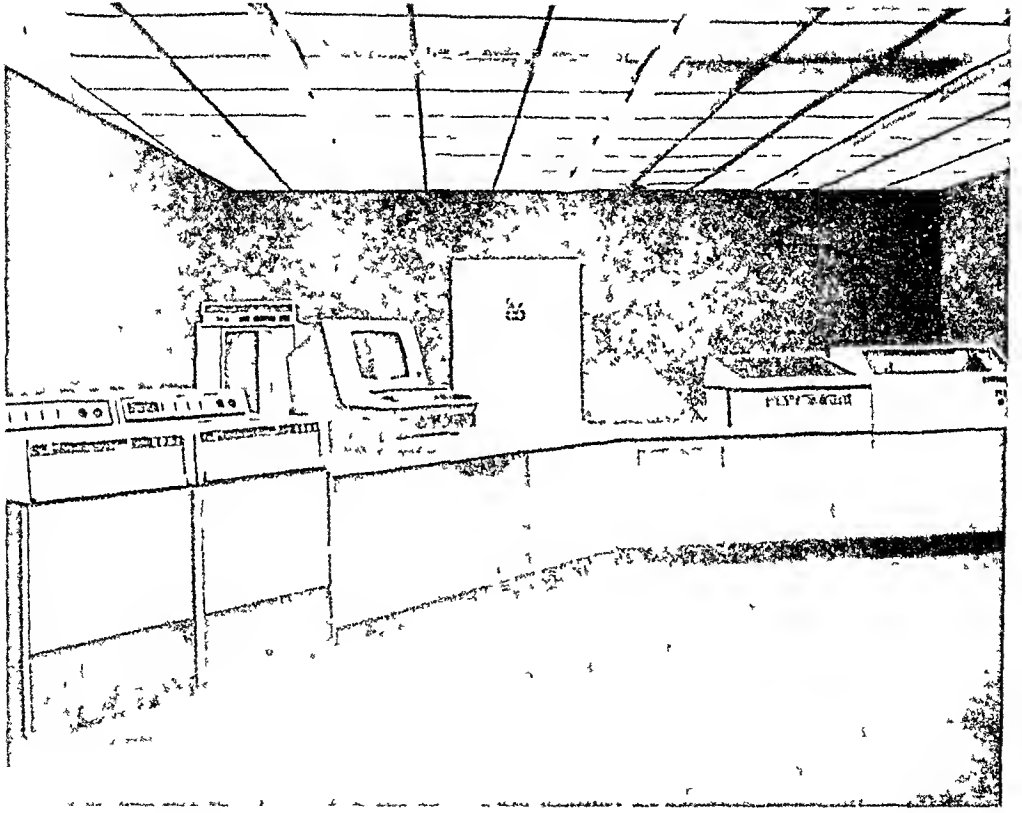
(See figure 12 2)

Working store The working store can be said to be the main memory of the computer The input data fed into the computer stays stored in the working stora Thus it provides the primary storage of the computer As and when the data is required to be processed or analysed or operated upon it is transferred to the Arithmetic/logic unit which does all the computation work like addition aubtraction multiplication and division The working store also stores the instructions (program) After process ng the data is again brought back and stored in the working store

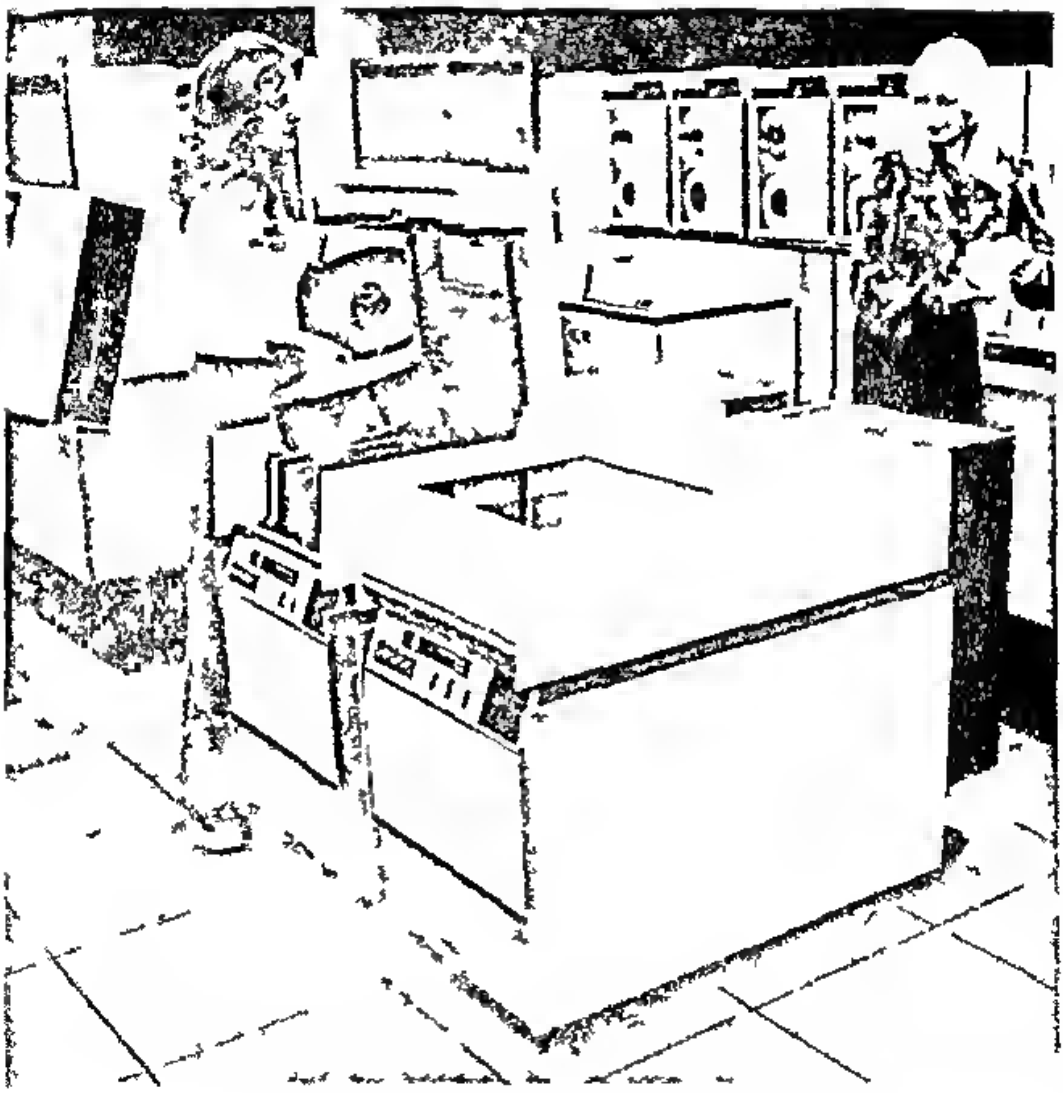
The computer can operate only on the data which is in the main memory If it is stored elsewhere as for example in magnetic tape it must be brought back to the main com puter The first one is known as primary storage and the second type is known as secondary or auxillary or peripheral storage

Basic concept of storage

Tiny magnetic cores form the computer storage It is made from a magnetic material like nickle zinc ferrite or nickle iron alloy Very thin wires which conduct electricity pass through these cores and these magnetize the core Depending upon the magnetic state the on or off position is determined These two states enable the data representa tion in the Binary system There are wires for sensing and reading the information There is also a logical ciscuitry

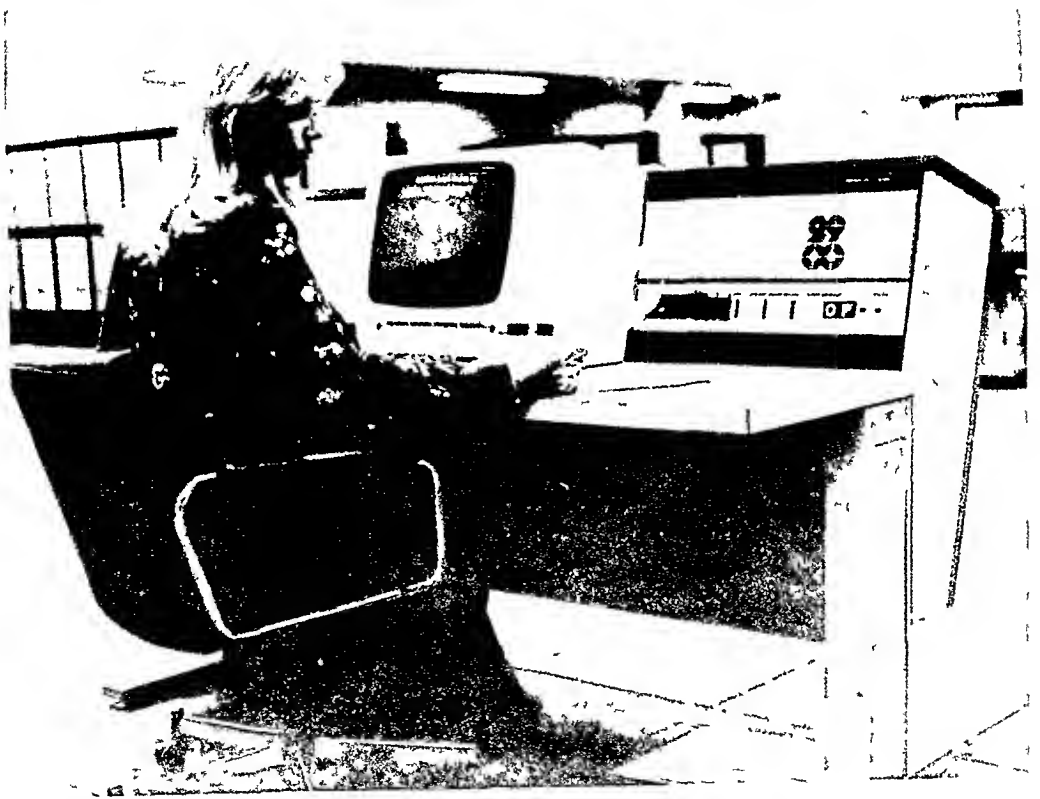


1 A Computer Installation



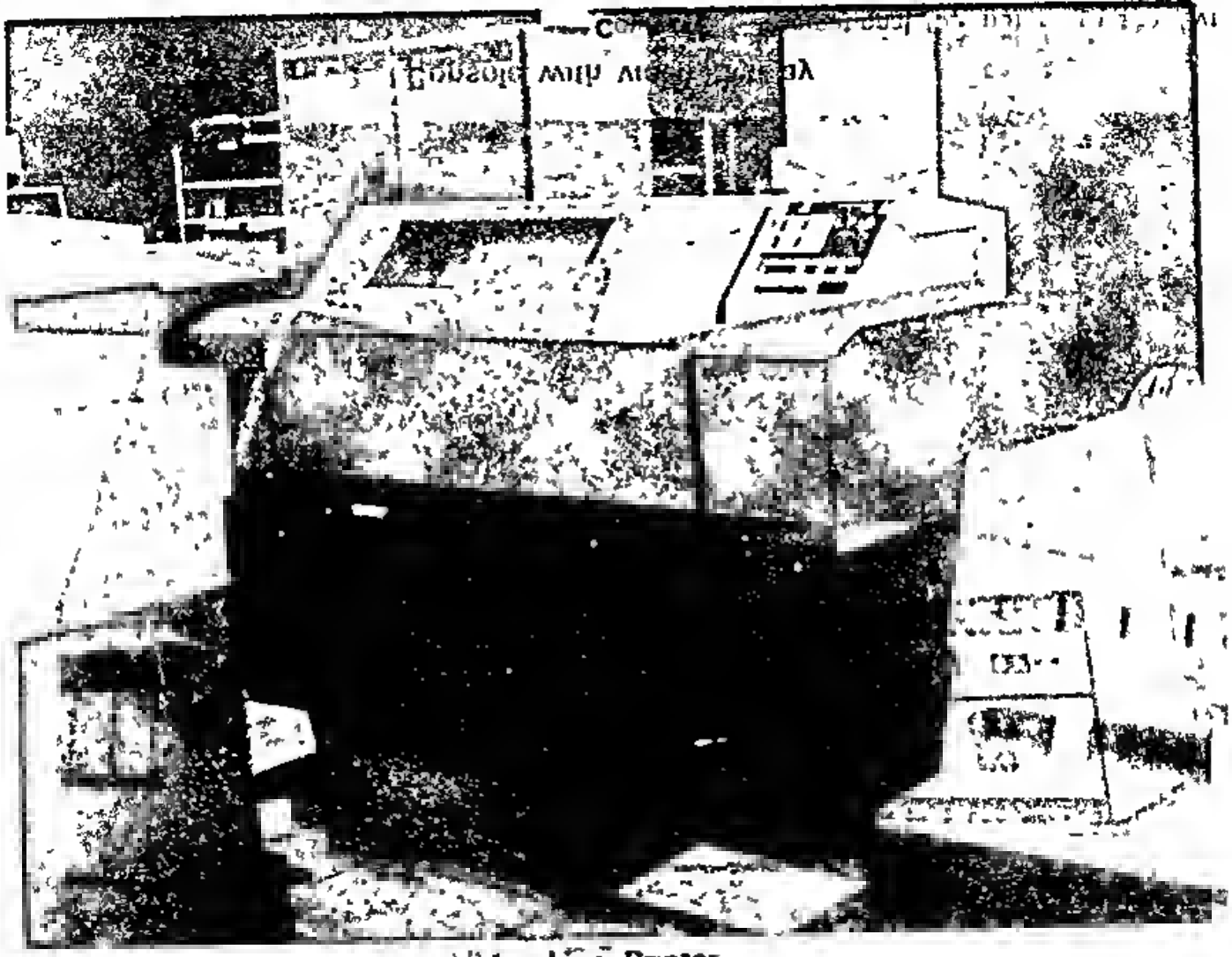
2 Exchangeable disc unit with magnetic tape units in the background

Courtesy International Computers (India) Pvt Ltd Bombay



3. Console with video display.

Courtesy : International Computers (India) Pvt Ltd Bombay



4. Line Printer

Courtesy : International Computers (India) Pvt Ltd Bombay

which codes and decodes information. A typical computer will have storage capacity ranging from 4K (4096 positios) to 512K (524288 positions). The magnetic cores are now being increasingly replaced by thin magnetic film memories and large scale integrated circuits (L.S.I.). The large scale integrated circuits permit more dense representation of data and provide for faster access speeds. Large scale integrated circuits are also known as monolithic storage. One consequence is that the size of computers has been considerably reduced even though their power has increased. This reduction in size of components and circuits and consequent reduction of space requirements is referred to as miniaturization. The other major advantage of L.S.I. is that it is more reliable and requires less maintenance. The large scale integrated circuits have a cycle time (time of one operation) of only 100 to 150 Nano seconds (one billionth of a second) as against 500 Nano seconds for magnetic core. The L.S.I. is also less susceptible to change in climatic conditions and consequently the expensive air-conditioning provided for earlier computers is no longer necessary.

In order that the instruction and data are accessible as and when required, each data element stored in a computer is given an address. Since each computer has a fixed core storage, the address refers to the core position or location where the data is stored. Each core represents one bit binary (binary digit) position. The number of bits required to represent a character depends on the coding system. The standard EBCDIC code requires 8 bit position. (See Chapter 11 on Data Representation where this has been explained in greater detail.)

Arithmetic/logic unit

This can be said to be the brain of the CPU—Here all the computation takes place.

The Arithmetic Unit in the CPU works in a very elementary way. In essence, it is capable of a single addition or subtraction. Multiplication is done by repeated additions and divisions by repeated subtraction. In view of the extreme simplicity of these units, the programme should detail every job in the most fundamental terms and as a corollary,

the Systems Analyst must provide the Programmer with detailed specifications to show how the computer system is to function When a job is broken down into such fine details care should be taken to see that there are no logical errors in the final specification

Although it is a simple device the Arithmetic Unit can perform at extraordinarily high speeds In comparison the input and output devices are extremely slow

Control unit

The control unit as the very name implies controls the movement and operations within the Central Processing Unit In other words, on the basis of the program fed into it the CPU ensures that operations as specified in the program are performed in the correct sequence This operation may be receipt of data and storing them at specified locations transfer of data from one address of working storage to another transfer of data from working storage to the Arithmetic Unit controlling the Arithmetic unit to working store and from there on to the output

Output devices

After the computer has processed the data the final result has to be brought out from the machine in some intelligent and readable form The result that comes out of the machine is called output and the equipment which enables the results to be brought out are termed Output devices

The common output devices are—

Card punch	— punches out results on punched card
Paper tape punch	— uses paper tape
Magnetic Tape Unit	— writes out results on magnetic tape
Magnetic disk unit	— uses magnetic disk
Line Printer	— prints results on paper

Computer software

To enable a computer to perform its various tasks coded instructions or programmes have to be fed into the computer hardware Such sets of instructions are described as computer software Readymade software for different types of applications are available from computer manufacturers

Software perform two main functions :—

1. Enables the internal control functions of the hardware to be carried out efficiently at the speed of the fastest unit of the computer, i.e., the Central Processing Unit.

2. Makes the task of programming easier and this, in turn reduces the delay before the user's machine can be made operational.

Greater details of the computer components discussed in this chapter have been given in the chapters that follow.

13. Input Media and Peripherals

In order that a computer may procass the date it is neces aary to have the data first converted into machine readable form using punched cards paper tapes atc This data is then read into the computer The input process takes piece in the following mannar

(i) When data is to be raad into tha computer a com puter inatruction is executed This specifies the address of the input device from which the data is originated and the address of the location in the computer memory where the data is to ba stored

(ii) The control unit which activates the mechanism for movement of tha data receives an electrical signal and sets the process in motion

(iii) The input device reads the data on the input medium and decodes the data into electrical signals

(iv) The control unit translates the data input code (Hollerith code) into the internal code or machine code of the computer (like EBCDIC) and transmits the data to the work ing store

(v) On ccmpletion of this operation a signal is transmit ted to the central processor indicating completion of the pro cess so that the subsequent item of the program in sequence can start

Several variations of these input media and peripherals are available and some of the common types are briefly dis cussed below

1. Card reader

A device that transfers data contained in punched cards into a computer is known as a card reader. It is connected to the computer and operates under its control. This is the most common type of peripheral. A card reader can read punched cards at rates varying from 300 to 1500 cards per minute. Some card readers can punch cards as well. The machine consists of a hopper, a reading station, a stacker and a card transport mechanism. The cards are placed in the hopper. Once they are read, they drop into output stackers. The cards pass through sensing stations to be read. The sensing stations have either wire brushes or photo electric sensing devices which can sense the punch hole. The photo electric sensing method uses a lamp with the light focussed on the card. There is an array of photo electric cells underneath the card. If there is a punched hole, light will pass through it and this activates a photo electric cell which tells the computer of the presence of the hole. The resulting electrical impulses are automatically converted into the coding used by the computer (its internal machine code) and the data is transmitted into the internal store.

2. Paper tape, punch and reader

The punched tape as an input medium has several advantages over punched cards, the chief of them being that fields of unlimited length may be recorded and being continuous, it allows easy handling (in real form) and cheaper transportation. However, unlike cards, it is difficult to insert new records or delete old ones.

Data is recorded on paper tape by punched holes across the tape. The specific positions in which holes may be punched are called tracks and the number of tracks (5, 6, 7 or 8) in which the tape code may be punched is called a row. Figure 13.1 shows an 8 track code. Each character is represented on the tape by a combination of holes in a row across the tape.

8-track tapes are more common as fewer tracks do not allow sufficient number of hole patterns to represent an adequate character set.

An 8-track paper tape permits 128 possible hole combi-

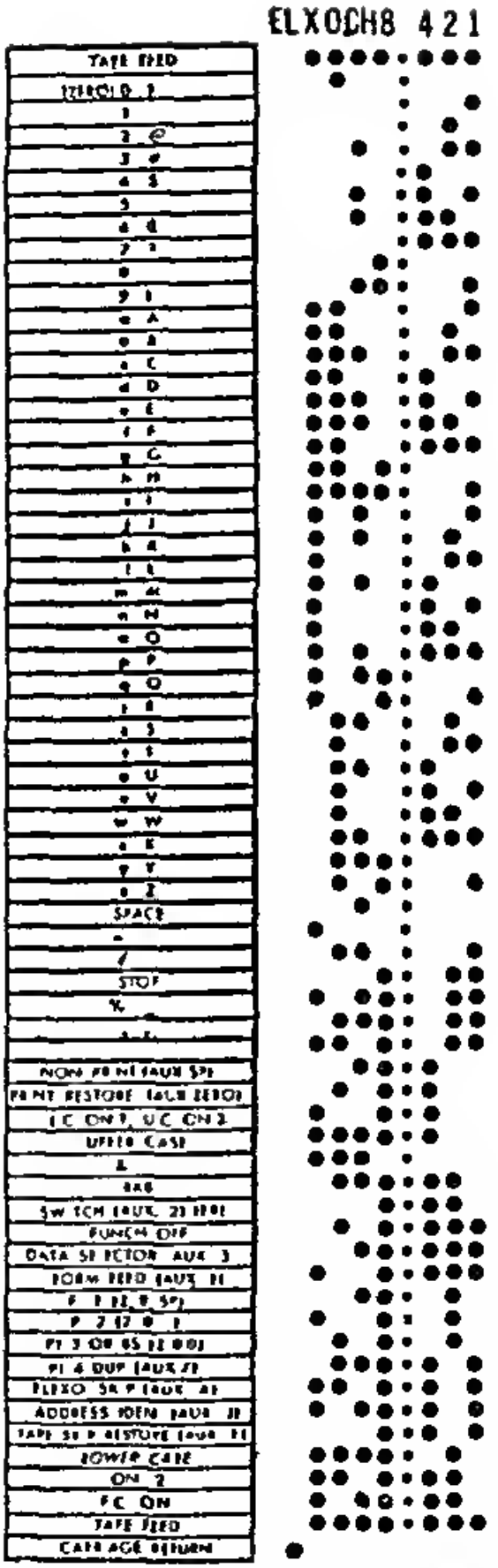


Fig 13 1 Punched tape showing eight channel code

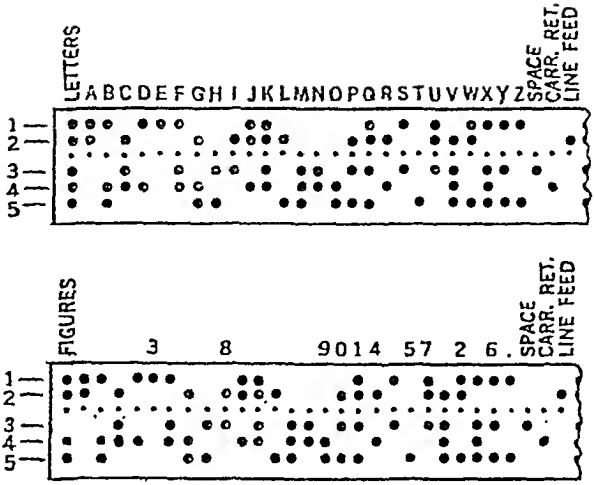


Fig. 13.2 Punched tape showing five channel code

nations and, therefore, 128 different characters can be represented. The last track of the tape is used for punching of a parity hole which is meant for checking. Data is punched on paper tapes in almost the same way as on punched cards. A key board punching machine is used for this purpose. Since there is no room on the tape to interpret the code punched, most paper tape punching machines also produce a separate typed copy of the data punched for checking purposes. The parity of each character punched is checked by the machine.

Paper tape readers are somewhat similar in operation to punched card readers. The reel of tape is held in a tape dispenser and passes through the drive mechanism and under the photo electric reading station. It is then allowed to fill into a large bin from which it can be reeled back after all the tape has been read. The reading speed is also higher than for punched cards and can range upto 2000 characters per second. The cost of paper tape is also much less compared to the corresponding cost for punched cards.

3. Magnetic tape

The magnetic tape almost resembles the tape used for recording on a tape recorder. It can be used for mass storage of permanent data, for interim storage of temporary data,

as working storage during a computer run, and for the storage and manipulation of programs In any system involving large volumes of data magnetic tape is invariably used as a storage medium Some of the capabilities of the magnetic tape are as follows —

(i) A single reel can hold as many as ten million characters of data

(ii) Data can be transferred to or from a magnetic tape at speeds of many thousands of characters per second

(iii) A reel of magnetic tape can be used repeatedly with old data being erased when the new data is recorded

(iv) Data recorded on a magnetic tape can be preserved indefinitely

(v) The length of tape is extremely flexible

The tape reels are mounted on tape decks connected to the central processing unit The machine consiste of several decks Data from the core store is recorded on the tape on tha instructions in terms of the progrem, end it is then read from the tape deck into the core store when required at a later date

Data is recorded on e number of tracks Some eystems use 7 tracks, while others use 9 Writing and reading cen be done with the tape moving in one direction only

Magnetic tape is used for holding data and programs Data can be input data for processing, i e , raw data It can also be in the form of a master file of permanent data for retention and periodic updating, i e , process data

Tapes can also be used for temporary data storage, while running a program

Tapes are usually written to by the central processor under the direction of a program To enter raw data on a tape, it can be first punched on cards or paper tape and then copied on magnetic tapes by a suitable program However, it is possible to type data directly on to a magnetic tape

4 Key-to-tape system

In a Key-to-Tape System the data is entered by means of a key board similar to a typewriter, directly into the magnetic tape, instead of first punching into cards end then hav-

ing it read into the computer. This is known as a direct entry system. To facilitate operation, a video display unit is attached to enable the operator to check the accuracy of the data while entering the same. Usually, the data is taken into buffer storage in the computer. After the entire data is keyed and the accuracy is established, it is taken either to a magnetic tape or a cassette to be used later on. The advantages of these systems are:

(i) There is no limitation of 80 column as in the case of a punched card. The problem of squeezing all data elements into 80 columns is, therefore, eliminated.

(ii) It is much faster as a data input device than punched card reader, as the recording is electronic.

(iii) By eliminating the need for cards the cost of the operation is brought down.

(iv) It is much easier to correct the error as there is no need to repunch the whole card. The operator has only to backspace and re-key the correct data.

5. Key-to-disk system

A more advanced version is the key-to-disk system. Here several key boards are connected to a magnetic disk through a mini computer. The computer itself performs several data verification and validation functions. The disk may be a permanent one or a removable disk known as diskette or floppy disk. The advantages of the diskette system is that the data can be captured at a remote location. The diskette is then flown to the main computer centre for further processing. Data can also be transferred through telephone lines to the main computer from the diskette. Though the key-to-disk system is faster, it is more expensive.

6. Magnetic ink character recognition machines

In addition to the punched card, a paper magnetic ink character recognition machine, which can read data directly from the printed paper, is increasingly used. This does away with the need to convert the data into punched card. Wide use of this has been found in the Banking industry where constantly information like customer's details, Cheque No. and amount etc., are recorded in magnetic ink containing

particles of iron oxide This is directly read into the com puter These are used widely in the Banking industry in U S A This enables fast p ocessing of cheques at speeds wh ch would have otherwise been impossible

7 Document readers

(a) Optical Mark Readers

These machines have a capacity to read punched holes computer generated marks as well as marks from ordinary pencil such as X I This has a reading rate of 200 cards per m nute These machines also can make meaning out of the presence or absence of a mark Here agaln by this process coding of data end punching into cards is avoided and through an appropriate coding scheme the data is read into the computer

(b) Optical Character Recognition Readers

Optical character recognition machines can raad ind vi dual characters at the rate of 150 to 1500 documents per minuta The main advantaga of this is that cod ng and pun ching errors are eliminated with the usa of pra printed codes and charactera Th s is an improvement over optical marks reader as it can read characters instead of marks The read ing is through a photo electric device

(c) Magnetic ledger cards

The other variation which is frequently used is the mag netic ledger card Here the record ng is done on a card which has a magnetic layer or stripe These are then fed into a magnetic card reader The main advantage is that the ind vidual records are available for immediate reference leav ing the computer to do further analysis

Point of sale terminal

Use of price tags that can be read directly into the com puter with all relevant information like price quantity etc is in widespread use in U S A These enable fast listing end preparation of cash memos and further processing of data It is expected that such systems would develop further

Audio response

The ultimate in data input is through voice, and experiments in this regard are being carried on. Even now the computer can respond to certain human inquiries made in a carefully controlled tone using set phrases. The perfection of this, therefore, can be said to be the ultimate in data input system.

14. Bulk Storage and Access Devices

Modern business requires a vast amount of data and information to be maintained, retrieved and used as and when necessary Computer storage may be classified into—

1 Internal storage
2 Auxiliary storage
3 Externel storage

The internal storaga forms an integral part of the computer and is directly controlled by the computar It is usually refarred to as the main or primary storage

The data in the main storage is automatically accessible to the computer However, to be easily accessibla, each data character should be stored in an identifiable location A sequential group of storage locations provides storege for one unit of data called a word or byte. Every word will consist of a number of digits or characters and may be of variable or fixed length depending upon the computer Each location is identified by an address, usually starting with 0 to the number required

An important feature of the main storage units is that each position must be accessible on a random basis, i e , the computer must reach any data storage point directly Further, the data stored must be capable of being used several times over without being erased till such time as it is no longer needed

The data in the main storage is received from an input unit The main storage exchanges data with and supplies

instructions to the central processor and furnishes data to the output unit.

The holding capacity of the main storage is, however, quite limited. For example, a 512K memory computer will have 524288 storage locations (or bytes). This is not sufficient to hold information which may be of the order of 100 to 1000 megabytes. As such, the main storage often holds data on a temporary basis for actual processing. The bulk of the data is held in an auxiliary or external storage device from where it is transferred to the internal or working storage when it is required to be processed and then returned back to the external storage. However, in some applications, in real time systems for example, it may be necessary to have the data, if not on the primary storage, at least somewhere from which it can be accessed fast. This has led to the development of bulk storage devices.

The primary storage is a magnetic core storage which was described earlier in Chapter 11. The access time is in nano seconds (billionth of a second). Since there is no need for mechanical intervention for accessing data, the access time is very fast. Due to developments in technology the storage costs have come down dramatically and today the magnetic core storage where the data is stored inside the computer, is the cheapest compared to magnetic tape or disk.

Auxiliary storage: This supplements the main storage of a computer and usually holds much larger amounts of data than the main storage. It can hold upto several hundred million characters of data in either sequential or random sequence depending upon the medium.

The data paths of auxiliary storage devices are always connected to primary storage. Since the route is through the primary storage, the access to data in the auxiliary storage is less fast than to the data in the main storage.

Like the primary storage, magnetic core forms the main device for auxiliary storage also. Besides there are other devices, e.g., magnetic tape, magnetic disks and magnetic drums.

External storage facilities provide a means of holding data or information before or after it has been processed by the computer. The storage is not an integral part of the com-

puter though the data stored is in a form suitable for direct entry into the computer External storage can be on punched cards punched tapes and magnetic tapes

Each of these storage devices have different capacities and capabilities usually mentioned in terms of access time and transfer rate The cost of the devices also varies consider ably

The ma n functions of these storage devices can be broadly summarised as below

1 To store extensive data files in a most convenient manner

2 To act as an intermediary storage where large volumes of data have to be processed

3 Store programmes and instructions to be drawn by tha Central Processing Unit as and when requ red

Since much of tha data processing activity in a business environmant is centered around data storage and retrieval it is worthwhile to study tha capabilities of these in detail It may be mentioned that tha selection of storage mada for a given installation requires careful evaluation of cost and per formanca

Magnetic tape

This is tha most common type of data storaga medium especially as it is very convenient to handle Tha tape which has a width ½ to 1 is covered by a thin layer of magnetizable material It is wound on reels very similar to the tapes used in tha tape recorder The reel diameter is normally 10 inches and has usually a length of 2 400 ft It is either 7 track or 9 track The 9 track tape usually has a density of 800 bytes per inch It has a transfer rate of 30 000 to 1 20 000 charac ters per second The 7 track tape works on the BCD code while the 9 track code works on EBCDI code The tape spe-d varies from 37 5 inches to 75/150 inches per second This gives a transfer rate upto 1 20 000 characters per second The information is recorded in parallel tracks

One way of understanding the speed of magnetic tapes is to compare them with punched cards In a punched card reader the card reading speed is approximately 2000 charac ters per second Thus a magnetic tape has a speed upto 60

times the punched card. The storage capacity of a magnetic tape can be from 5 million to 22 million bytes. To represent 1 million characters, 12,500 punched cards would be required. One other advantage with the magnetic tape is that it can be reused, while punched cards cannot be used again. Magnetic tapes are also easy to handle. A magnetic tape is, therefore, vastly superior to a punched card as a storage medium. It is for this reason that modern computer systems work on direct entry (key-to-tape) device doing away with the punched card.

Information is stored in magnetic tapes in blocks. Each block of record is separated by a gap called inter block gap (about $\frac{1}{2}$") in which no data is recorded. This is essentially to facilitate the transfer of data to the main computer. By keeping the ratio of recording block to inter-block gap to the minimum, the utilisation of the tape can be increased.

Another point to remember in the case of tapes is that it is a sequential access device. In other words, if any information in the middle of the tape is to be accessed, the tape has to be moved in the reels to that particular position. This naturally delays the accessing of information. Tapes are, therefore, not very suitable for on-line systems where the information has to be accessed very fast and also constantly updated. Magnetic tapes are, therefore, used mostly in batch processing applications where the transactions are first sorted out before processing in batches in a particular sequence. File organisation in magnetic tape is also sequential. In a sequential file it would be necessary to search the file in sequence every time a specific record is to be located.

Magnetic disk

The magnetic disk is a thin metal disk resembling a gramophone record. It is coated on both sides with magnetic recording material and each disk surface consists of a number of concentric bands along which data may be recorded.

The disks have concentric tracks and data is stored on these tracks, in magnetised spots arranged in binary form. The data is recorded serially bit-by-bit, eight bits per byte

along a track The disks are mounted in a stack on a rotating vertical shaft Enough space is left between each disk to allow the access arms to move in and read or record the data The access arms have two recording heads and can read or write on either side of a disk As the disks rotate they can be written to or read in the same manner as on a magnetic tape

A single magnetic disk is capable of storing as many as one hundred million characters Usually more than one disk unit can be attached to a computer Data seek time is about 30 milli seconds and rotational delay is 8 3 milli seconds Once the data is located transfer rate is 806 000 bytes per second

Each record on the disk has an address and can be accessed directly at great speeds It is because of this that it is called a direct access and random access storage device

Magnatic drum store

While the magnetic disk has tha advantage of random access and large capacity it is slower than the magnetic drum In order to optimise tha use of the CPU the magnetic drum is used The magnatic drum stora is cylindrical in appearance with a magnetisabfe outer surface As the drum rotates at a constant speed data is recorded or sensed by a set of read writa heads The drum has 800 tracks. Tha data is transferred in blocks Each track has a storage capa city of 5160 characters and an average magnetic drum can hold 2 million characters The drum has a rotating speed of 3500 RPM and has an average access time of 10 milli seconds The data transfer rate to and from a processing unit may be upto 1 200 000 bytes per second The speed of the drum makes it one of the best substitutes for the main store

Magnetic card store

For large data storage magnetic cards can also be used This has a size of 16" by 4 5 and has 128 tracks where data can be recorded In each track 2048 bytes of information can be stored 256 cards so combined form a magazine To

facilitate reading, the cards are fed over a rotating drum. It has eight write-read heads. The total storage capacity available in the card store is as large as 536 million bytes.

These cards have a slow access time, viz. 470 milliseconds on an average. The data transfer rate is, also low, viz. 70,000 bytes per second. Ccnsequently the use is very limited. The only advantage is its capacity to store voluminous information.

COMPARISON OF BULK STORAGE DEVICES

	Magnetic Tape	Magnetic Disk	Magnetic Drum	CPU Primary Storage
Capacity range	5 to 22 million bytes	Upto 100 million characters	Upto 2 million characters	Upto 4 million characters
Access time	Depends upon location as it is sequential.	30 milliseconds	10 milliseconds	Cycle time in nano seconds (billionth of second).
Transfer rate	30,000 ch/sec. to 1,20,000 ch/sec.	Upto 8,06,000 ch/sec.	Approx. 12,00,000 ch/sec.	

15 Computer Software

We have seen that various units of the computer system perform different functions relating to data processing Data that is received by the computer is operated upon and output information is processed A constant communication between the various units of the computer takes place—communication batween input device and working storage tha working storage and arithmetic or logic unit and the working storaga and control unit etc This communication is made possibla through a series of instructions fad into the computer A set of such instructions written to perform a task or solve a problem is termed a program

As was stated earlier one of the landmarks in computer technology development is the stored program concept Under this concept the instructions are stored in the memory of the computer This is considered to be a significant advance over the earlier data processing machines operating under the Unit Record System

Instructions for computers

The binary machine code is the only language which the hardware of a computer can understand and interpret This language is very difficult for human beings to comprehend and interpret Just imagine writing rows and rows of binary digits Apart from the tedium the probability of error also can be very high To overcome these problems programming languages have been devised which are easy

to understand and to use. The programs written in these languages are made comprehensible to the computer by being translated into machine code by a special program called a Compiler, also called assembler or translator.

The entire process can be described as follows:—

(a) Instructions are first written in a language understood by the human being. This is known as source program.

(b) These instructions are then translated into machine language. This is known as object program. This is done through the help of a compiler. Each type of computer has its own compiler. Machine language for one type of computer cannot normally be used in another type of computer.

(c) The machine level instructions are then converted into electrical impulses.

(d) This is the reason why programs are written in a source language like COBOL which is common to most of the computers.

Low-level and high-level languages

It will be seen from the above that three steps are involved in the whole process. However, it is possible to do away with the first step by writing the programs in the machine-level language itself.

Programming languages which are close to machine code are termed as low level or assembly language. However, such low-level languages have several disadvantages, the major ones being as follows:—

1. It is a very tedious process to write these programs and it is possible only in small computer systems.

2. Programming capability will be limited only to some technical staff who may not have the necessary Systems background.

3. Programs will be different from machine to machine.

Because of these limitations, high level languages have been developed. A high-level language is not designed for a particular computer. It is close to human languages and can be designed to solve particular kinds of problems. These languages are problem-oriented and not machine-oriented as the low-level languages are.

The developments in programming languages were basically aimed at—

1 Bringing the user closer to the computer by allowing him to write the programs in higher languages These languages are common to all computers and this obviates the necessity for the programs to be translated into the machine languages

2 Languages were developed to exploit most effectively the computer circuit and design For example PLAN is the language which gets the maximum benefit out of ICL systems

3 Developing composite instructions which relieves the programmer of writing and repeating long and tedious instructions thereby leaving him to concentrate on other items of work that require more intelligence like programs for sorting information

4 Developing common programs with built in flexibility which would meet the needs of various users thereby relieving each user of the task to develop his own program Examples of this nature are linear programming package inventory control package etc

As was mentioned the term program rapresents the instructions that are to be fed into the computer Briefly these instructions are —

1 Those that enable the computer to store the information including the specific places where the information is to be stored (addresses)

2 Those that enable the computer to transfer the data from one unit to another unit of the computer This movement may be purely temporary

3 Those which cause a specific operation to be performed as an addition or multiplication Such instructions are broadly classified as data manipulation instructions

4 Those which enable the computer to communicate with the Input and Output devices

In addition modern computers have to deal with several complex computations for which instructions have to be given to them Some typical instructions would include

program control instructions which will assign priorities for various jobs where multiprogramming (where more than one job is handled) is involved, or switching controls from one job to another for better utilisation of computer facility.

Programming languages, like most languages, have a definite grammar. The concept of programming language can be best understood only by a methodical study of the language and practical application of the same. It may further be stated that the understanding of computer technology is not complete unless one has a practical experience of programming. The best way to understand a computer is by knowing how to communicate with it.

Computer software

The result of these developments in the field of programs is broadly known as computer software. Computer software has today become a multi billion dollar industry in U.S.A. and elsewhere. It includes programming languages and translators (which translate one language to another) and operating systems (which control the complex operations inside the computer).

Software packages for various specific applications are provided by computer manufacturers. These software consist of a program or set of programs designed for a particular application or to solve a particular problem. Software packages are of immense value to the computer users as they save valuable time, effort and money in programme development and testing. The package is usually thoroughly checked and tested and is usually quite flexible offering sufficient scope to the user to adapt it to his requirements.

The main benefits of software packages to the user are—

(a) Systems development cost is considerably reduced.

(b) Since these packages are developed normally either by manufacturers or software specialists the best expertise would have gone into the development of the system.

(c) Programming costs are reduced to the minimum.

Programming languages

Computer programming languages are divided broadly into three categories —

1 Assembler language
2 Problem oriented language
3 Special purpose language

Assembler language This language is close to the machine language and hence a low level language In the instructions the operations and the locations (operand) from where the date is to be obtained for performing certain operations like additions are specified in mnemonic (memory aiding) symbols and locations holding data are given symbolic names for addresses For example LA might be used instead of the machine language code 01000001 For each assembler language instruction one machine language instruction is generated The mnemonic code is translated by the compiler into the appropriate machine code operation and symbolic names are translated into suitable numeric addresses One advantage with assembler language is that instructions can be changed as the operations take place as the programmer can closely visualise the operations This is mainly because the programs can work at the level of the computer's basic circuitry and memory

One such commonly used Assembler language in India is Autocoder language which is the programming language for IBM 1401 series computer

Problem oriented language High level languages are—

* ALGOL (algorithmic oriented language)
* FORTRAN (formula translator)
* COBOL (common business oriented language)

ALGOL and FORTRAN are designed to solve scientific and technical problems and COBOL is designed primarily for commercial applications

The principal advantages of high level languages over the low level languages are

1 They are easier to comprehend and learn
2 They are easier to write and also to correct, if anything goes wrong

3. They are machine-independent and programs written in high-level languages can be run on more than one type of machine. The user is relieved of the responsibility of writing the tedious routines. This work is done by the language translator program called compiler.

4. The languages bring the non-professional user closer to the computer, thus reducing the communication gap between the man and the machine.

The ease with which a language can be used for a particular application determines whether a language is scientific application oriented or business application oriented. The main difference is that in a business application, a large amount of data is processed and the applications are input and output bound. There is constant updating of files and routines like merging and sorting are common. In such cases, the power of the computer is of lesser consequence than the speed with which the input and output peripherals operate. In the case of scientific applications, the processing speed of the computer becomes more important.

Special purpose language: These are languages developed for solving a particular problem. The most typical of the special purpose languages are those which translate one script to another. PL/1 is considered as general purpose language useful for both business and scientific applications.

Program flow chart

Before a programmer starts writing a program, it is necessary to prepare the program flow chart as was explained in Chapter 3. This flow chart will bring out clearly the program logic and sequence of operations. It may take several efforts before the final flow chart emerges, depending upon the complexity of the problem involved. Once the final chart emerges it becomes a useful document. particularly if and when the reference is to the program. The sequence will be somewhat as follows:—

(i) Using the standard symbols, the program flow chart is first finalised.

(ii) The program is written in the program language adopted, in special program work sheets. The final program

sheets form a very useful record for future reference

(iii) Program cards are then punched

(iv) The program is tested for any syntax (language) errors

(v) The program is then run on test data to test the accuracy of the program logic

In any data processing system it is necessary to prepare a manual giving full description of systems programs and operating instructions The program control error listing and result of test runs etc should also be properly documented All these prove an invaluable reference for a future date Testing of a computer program for identification of errors is commonly known as debugging of the program

Computer Utilities

Normally manufacturers themselves provida the user certain programs to carry out normal routines like sorting etc This is known as utilities provided by the manufacturer The functions of these utilities are

1 Effective and easy use of various peripherals

2 Simplification of the programming in general The programmer can use one instruction thus saving his effort and time

3 Ease of maintenance of program and system libraries for which control programs are readily available

4 Provision of standard sort/merge procedures

Typical examples are ICL s TOP 10 SORT which arranges records of one or more files in user specified sequence Other utilities by ICL are ITPS 10 (In House Text Preparation System) OOT (Dynamic Debugging Technique) MCS (Message Control System) TECO (Text Editor and Corrector Program) etc

Several hundreds of these routines are normally available with computer manufacturers While the cost of developing them independently is high the cost of acquiring these utilities is also substantial Therefore care should be taken to ensure that the user selects only those that are most appropriate to his needs

Programming in COBOL (Common Business Oriented Language)

There are four major divisions of a COBOL programme called the Identification Division, the Environment Division, the Data Division and the Procedure Division. The four divisions must appear in the program in the order just stated.

1. Identification Division

This division identifies the program, the programmer and the installation. The clauses of the Division are PROGRAM-ID, AUTHOR, INSTALLATION, DATE-WRITTEN, DATE-COMPILED, SECURITY and REMARKS. The PROGRAM-ID clause is compulsory as it defines the program name which is to be referred to by the compiler and computer operating system later. The order clauses are optional.

2. Environment Division

The clauses of this division specify the source computer (on which the program is compiled), the object computer (on which the program is to be executed), special names for the hardware facilities and the logical device (on which the file is placed). These clauses are defined under the two sections called configuration Section and Input-Output Section. In an installation having multiple Input/Output devices each file is assigned to a particular device in the programme itself.

3. Data Division

In this division the data required by the program is declared. The data division is further divided into various sections to declare data and other elements that take part in processing, in a systematic manner.

(a) File Section

In this section the Input/Output area, record format and the names of their components which are referred to during processing are defined.

(b) Working Storage Section

In this section, the information which is not the part of the Input/Output is described. The program also defines

the areas where the intermediate calculations, results of the processing are stored in memory and used in further processing

(c) Linkage Section

In this section the format of the data is declared which is used by the program by calling to another COBOL program to carry out a specific job

(d) Report Section

The layout of data and their format to be printed on printers are defined in this section

4 Procedure Division

In this division the computation, the logic of the program and the sequence of the operations to be carried out to produce the required results are stated The procedure division consists of paragraphs statements and sentences The elementary unit of the language used in this division is a statement introduced by a verb It consists of a single logical operation, e g ,

ADD A to B

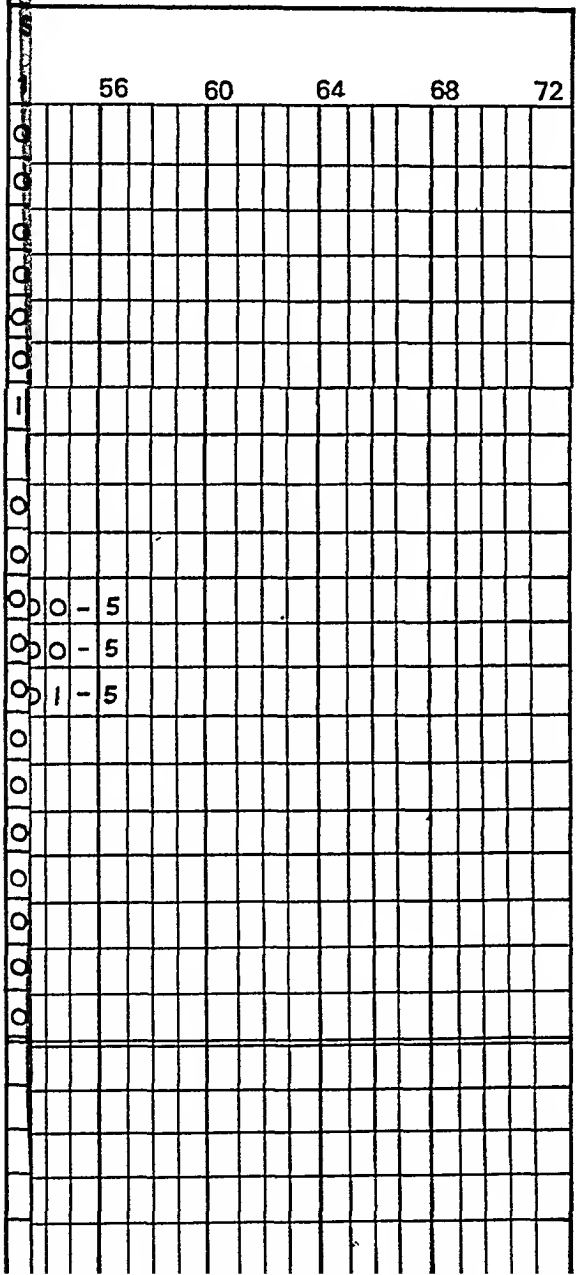
GO TO START

One or more statements can be grouped together, separated by commas or semicolons to form a sentence which is terminated by a full stop A sentence has an arbitrary length and a single statement sentence is quite common

Sentences are grouped together to form a paragraph A paragraph consists of a paragraph name followed by a period and one or more sentences Paragraph name has no meaning in the program except in understanding what paragraphs do and how they are related to each other It also facilitates the program to act on the set of statements by giving only one instruction and start acting on the statement which is not the next sequential statement

An example of use of this language in an application involving the various operations to generate a report of Customer Receivable Accounts from the Customer Master File and Transactions File is given in Appendix 3 and 4 as an illustration The operations involved are as under

	Sheet——of——
orm No.	Identification 73] [80



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16 Output Devices and some Advanced Computer Concepts and Systems

There are threa main reasons why outputs from com puters ara required

1 For communicating to the peopla concerned

2 For ra input to the computer for being connectad with other data and further processing

3 For permanent storaga

Tha most commonly used device for providing output in a readabla form is the line printer A device for providing output in a graphical form is the graph plotter

When data is to be stored or ratained for ra input a magnetic tape or disk is usually used Punched cards or paper tape are also used but these are comparatively quite inefficient

Two devices which can be used both for input and output are the teletypewriter and the Video Display Unit

Line printer

A line printer operates on the same principle as a type writer There is a type slug and an inked ribbon The basic difference is that while in a typewriter one letter after the other is printed in a line printer a whole line is printed in one operation

There are fast printers having a capacity to print upto 1000 lines per minute These are electro mechanical devices Continuous stationery is used for printing the output This printing may be done either on blank forms or on pre printed

forms. The most common type of pre-printed forms are the electricity bills, invoices, examination mark sheets, etc.

The operation of the line printer is controlled by the program fed into the computer. The instructions can be quite flexible and will include instructions for several details, including spacing. The stationery also need not be set to a fixed standard length and width. Normally 4 to 5 good copies of the printed output can be had. Some modern printers facilitate printing on two separate sheets by providing separate printing sets. This increases the utilisation of the printer's capacities.

Since the printing speed is slower than the data transfer speed in a modern computer, buffer storage is provided so that the data can be accumulated in temporary storage, leaving the central processing unit free to do other jobs.

Visual display units and conversational devices

Video Display Unit (VDU) : The video display units enable a message to be displayed on the screen, which is similar to a TV screen in appearance. Messages upto 2000 characters can be displayed. This is used very commonly in the situations like bank teller systems and airline reservation systems. In these cases the response to the query has to be immediate as there will be a queue of customers waiting for a reply. The only disadvantage is that the printed copy of the output is not available for future reference.

Graphic Plotters

The graphic plotters plot the graph on the basis of the program executed by the computer. It is increasingly used in statistics, architecture and planning systems. These plotters enable three dimensional representation.

Computer Console

In all modern computer systems a computer console is provided. This enables the console operator to monitor and control the activities of the computer. In third generation computer systems, it is essential for the operator to keep track of the various activities that are taking place. In particular, the operator should know which program is in what stage of execution. The console has lights which indicate various conditions, like, for example, error condi-

tions The console operator communicates with the com puter on the following items —

1 Program address
2 Operation instructions including assigning of perl pherals
3 Error communications and corrections
4 End messages
5 Security messages

Intelligent terminals and data communication systems

The traditional system requires all peripherals and the computer to be located at one place The source documents ara brought to the main computer centre and processed This in many cases involves considerabla delay in transport ing the documents It also adds to the cost of validating the data In order to cut such delays modern computers can ba connected to the terminals located at a distanca Tha terminals hava varying capacities ranging from mere transmission of data to executing part of the program and reviewing and printing the final output Tha advantaga is that a small terminal can make use of tha facility of a power ful computer system It also enables a small business orga niaation with small resources which cannot afford a good system to have a tarm nal installed in their location connect ed to a powerful outside system This is known as a tima sharing plan These systems are known as data communl cation systems This is an area which Is new and fast developing

The terminals are connected to the main computer through data commun cation channels In the United States of America it is expected that 2 million of these data terml nals would shortly be in operation These are also known as teleprocessing systems

The main components of the data communication sys tem are —

1 Main computer
2 Communication control unit
3 Modems
4 Communication network
5 Terminal

The system operates as follows. The data is first entered into the terminal and is converted into signals by a device called modems. These signals are then reconverted at the receiving end by another data set. The first process is known as modulation and the second process is known as demodulation. The communication is through special lines, either telephone lines or micro-wave channels. The transmission lines are classified as :

1. Simplex — Transmission in one direction.
2. Half duplex — Transmission in both the directions but one direction at a time.
3. Full duplex — Transmission in both the directions simultaneously.

The transmission lines can use EBCDIC Code or ASCII Code (American Standard Code for Information Interchange). The first one is eight bit code while the second one is 7 bit code. These are improvements over the earlier 5 bit code known as Baudot Code.

Data transmission by data communication lines results in errors in transmission. Special techniques are adopted to reduce the error rates in transmission. The common techniques are the parity check, block parity check and loop check (These are discussed in detail in a subsequent chapter dealing with audit and control).

Mini computer

With the development of memory technology the cost of computing has come down drastically. The latest trend is to have a small computer system with a card reader and printer connected to the main computer. The advantages of this system are:

1. Minor jobs and programmes can be run locally to meet local needs reducing the load on main computer and transmission.
2. Validating all input data before transmitting to the main computer and also correcting errors and retransmitting.
3. Provide for Printer output or display unit so that the results of processing on main computer are immediately

available In India a good mini computer system is available for Rs 6 00 000 to Rs 10 00 000

Multiprogramming

Out of the main disadvantages of the earlier computers were that the Central Processing Unit could handle only one program at a time This resulted in the Central Processing Unit remaining idle when the Input and Output operations were being carried out The reasons for this is that Input and Output peripherals operate very much slower than the CPU In order to improve the performance of CPU the computer architecture has undergone major changes Separate channels are provided which control Input and Output operations Buffer storages are provided which accumulate data While Input and Output operations are carried on this leaves the main CPU free to do the faster work This has resulted in the computer being abla to handle more than one job I C L System 2900 series for exampla can handle 15 programs simultaneously This is particularly useful in business applications which are highly Input and Output bound joba Multiprogramming is achieved in the following manner —

The main storaga is partitioned and allocated to various programs Priorities are arranged to various programs Special protection features ensure that there is no overlapping The entire control is handled by an operating system residing in the main memory

There are two types of channels Sector channels which control faster peripherals and multiplexor channels which control slower peripherals

Cost of computer system

The cost of computer system varies considerably and depends upon the Hardware features desired The cost could be anywhere from Rs 0 5 million to Rs 20 million Similarly, the cost of software also varies considerably The same is the case with Input/Output peripherals and bulk storage devices Before acquiring a computer system detailed evaluation of cost and resulting benefit should be carried out

17. Data Processing Management

Activities of the Data Processing Department

Originally the main function of the data processing department in an organisation was to look after the management and administration of the data processing activity involved in maintaining a Unit Record set-up or a small computer set-up. This did not pose any great problem as both the capabilities of the system and the scope of application were limited. Most of the applications were finance or accounts oriented. The financial accounting systems were developed by finance personnel and these were then converted into a mechanical system. It is for this reason that initially, in most of the companies, data processing remained an accounting responsibility.

However, with the development of total systems concepts, it was recognized that financial applications were only one part of the total system. In fact, the application of computer systems in other areas of operations like production, inventory control etc. brought in the maximum benefit. This, coupled with developments in data communication technology and advancements in computer hardware and software, has brought about a total change.

E.D.P. is no more considered a part of the finance function. It is a separate entity forming part of Management Information Systems. The routine involved in maintaining

a computer installation is only a small part of the total function

The far reaching developments in the information science has brought about the following changes —

1 The Electronic Data Processing Department is being given higher status in the organisation reflecting its changed role Increasingly EDP Managers are reporting directly to the Chief Executive

2 With the need to create complex data bases the lead time for developing systems has increased This is reflected in higher systems development budgets

3 Consequent to the discipline that is to be maintained to sustain the system Managers at all levels are becoming more systematic

4 With the realization of the capabilities of the computer systems there is increasing pressure from various functional units for computer time and other system services This has resulted in data processing managers having to carry out in depth studies of Management information needs and assign priorities Such studies have toned up the quality of management in organisations

5 The method of estimating the benefits on account of computerisation has changed It is no more related to the direct savings of cost on account of labour etc

Data processing activities can logically be grouped into three categories

1 Planning functions

This includes preparation of long term and short term plans relating to determination of Hardware and Software and programmes for acquisition thereof preparation of budgets and cash flows and drawing of detailed schedules leading to the installation of facilities finalising long term plans for systems development data bases planning manpower requirements and drawing manpower development programmes

2 Systems development

In consultation with the user department and with the approval of Management at the appropriate level design new

systems, standardize existing systems and carry out modifications for existing systems. The systems development work would cover the related software and programming work.

3. Operations

This includes all matters pertaining to installation, running and maintenance of all facilities and equipment, organising input and output programme modification, maintaining proper controls and security of all data and jobs.

The above items are indicated only by way of illustration.

Thus it is obvious from the above that the role of the System and Data Processing Department has undergone considerable change. In keeping with this new role, the responsibilities or functions of the EDP Manager would be as given below :

1. Hardware

Carry out detailed studies on the type of hardware that is available and determine the current needs and estimates for the future. Carry out detailed technical evaluation and prepare cost benefit reports. Hold discussions with the manufacturers with a view to determine the suitability of the hardware to meet organisational needs.

2. Software

Examine the software that is currently available with regard to quality and price. Determine with reference to the organisational needs, the software to be developed internally and to be procured outside.

3. Systems development

In consultation with user departments, draw out a systems development plan both long term and short term, and determine system priorities. Allocate personnel and control the time costs.

4. Maintenance and running of current system

Total responsibility for ensuring that the current systems are operated and maintained according to schedule and

standards set This includes proper maintenance of the facilities, drawing up of operating schedules, organising and controlling input data and ensuring that the schedule of output is maintained This also includes system tuning and modifications, setting standards for all data processing routines and activities and ensuring co-ordination with the user.

5 Compiling long term and short term capital budgets and operating expense budgets

6 Training of the EDP and non-EDP personnel

7 Administer the management development programme of all staff engaged in the EDP activity

The Data Processing Manager would be assisted by a number of staff and line managers Normally the work is divided into two categories :—

1 Administration of facilities and maintenance of current systems

2 Planning and development

The planning and development function for a large organisation would normally have the following staff advisers :—

1 Data communications specialist
2 Data Base co-ordinator
3 Operations research applications specialist
4 Application software specialist
5 System software specialist
6 Training methods specialist
7 Control security adviser.
8 Systems analyst and programmers

The operation group would consist of

1 Computer operations manager
2 Maintenance manager
3 Chief programmer
4 Systems manager
5. Systems analysts
6 Maintenance programmers
7 Data collection controller
8 Data output controllers

Location

One of the important organisational matters pertaining to the data processing department is the location of the

facilities. Normally in small organisations with one or two Production and Distribution Units. the location of the department does not create any problem. But in a large organisation with multi-units the question does arise whether to have a central processing unit or have a regional processing unit.

The advantages are:

1. A central set-up will be less expensive to operate than individual regional units.
2. With all data processing activities under one roof, the problems of management will be less.
3. By eliminating one stage of transmission of data, the processing of final data will be done faster.
4. Duplication of work is avoided and certainly facilitates more efficient data management.

The disadvantages are:

1. Logistic problems in transmitting data from remote units.
2. No stand-by facilities; if the central unit is out of action, the entire system stops.

The data processing department is normally headed by an EDP Manager who may report to the Director, Information Systems or the Finance Controller. His main job responsibilities have been detailed earlier.

Introduction of a computer system

Before embarking on a decision to introduce a computerised system in any organisation it is necessary to prepare a detailed feasibility report.

The report would exhaustively cover the following aspects :—

1. Study of the present organisation with particular reference to the problems in the areas of communication and information and data processing in relation to achievements of its corporate objectives.
2. Assess the current information that is being processed at all levels of management.
3. Present system of data processing and its limitations.

4 Determination of future MIS (type of reports frequency, due dates etc) with particular reference to the data base that would be required to provide the information

5 Hardware requirements with particular reference to availability of supply, source of supply, Equipment costs

6 Software requirements

7 Manpower plan

8 EDP organisation

9 Cost benefit analysis of the proposed system

10 Plan of implementation with particular reference to time schedule

Where a decision is taken to obtain a computer on ownership basis a more detailed plan is prepared for acquisition and installetion of the computer The system development work should take place concurrently so that when the computer is installed the systems are ready for implementation In many organisations this espect has not been given sufficiant importance resulting in the computer remaining under-utilised for a very long period of time

Hardware selection

Once it is decidad to instal computar facility it will be necessary to finalise the appropriate equipment

Since different computer systems have different capabilities It is not always easy to finalisa a particular system Various factors are taken into consideration and suitabla weightages are given

It is normal practice to test a few selected programmes particularly where the programmes are already developed to test the capabilities of the system

Some of the important considerations that go into the selection ere

1 Cost

2 Hardware capacity like memory features instruction times, computational capabilities methods of data transmission, types of data accumulators and registers modularity (expandability of system), error detection features power failura detection features and memory protection features

3. System reliability.
4. Software variety and quality, particularly whether it is a proven software.
5. Maintenance facilities.
6. Back-up facility

It is usual to call for detailed quotations from the manufacturers. Discussions are then held ,with the suppliers and wherever the systems are available, they should be thoroughly tested with live programs and data.

It is advisable to study in depth the manuals that form part of the system to understand the exact capability of the system before the final decision is taken in this regard.

Maintenance of a system

Since computer hardware is very expensive it is necessary that the system remains operative and fully utilized. In many cases due to the failure of one of the peripherals, say, line printer, the entire system stops functioning. It is, therefore, necessary to ensure that proper maintenance facilities exist. There are two possibilities in this regard:

1. Maintenance by manufacturers.
2. Maintenance by an outside specialist firm.
3. Maintenance by our own staff.

This requires a very careful evaluation. While the maintenance arrangement by the manufacturers is the best, it is not possible in India in the case of imported systems. In the Indian environment, the choice appears to be between 2 and 3.

In any case, it appears that a balanced approach would be to have a routine maintenance carried out by one's own staff with outside expertise being called in the case of a major breakdown.

The point to be remembered is that a proper maintenance of data processing facility is a very important aspect of data processing management.

Cost benefit analysis

The cost of data processing system and facilities can be quite substantial. Therefore, careful evaluation of costs and benefits should be continuously made. The cost may vary

from one million to ten million rupees per annum Saving of even 1% would be quite substantial

At every stage of decision a detailed cost benefit ana lysis is made It is first made at the time of introduction of a computer as part of the feasibility report The cost bene fits are evaluated taking different alternatives that are avail able

While the cost of the equipment can be ascertained with some amount of accuracy the benefits are more difficult to estimate This is because apart from tangible benefits it is the intangible benefits that go to justify the system Never theless a good manager should be in a position to quantify the intangible benefits

To take an example of computerisation of inventory system the benefits of the system can be grouped into three categories

Direct cost reduction This applies mainly to reduc tion of clerical costs stationery costs and office space reduc tion directly arising out of the introduction of a system These can easily be measured and quantified The chances of estimates of such savings going wrong are considerably less

Increased efficiency in purchasing With improvement in the quality of information it is possible to reduce the in ventory level say by 25% The savings in the interest can be worked out However the risk of the actuals differing from the estimates is high

Prompt settlement of bills Through a good compu terised system the suppliers bills can be settled in due time resulting in greater supplier satisfaction This is parti cularly so in large organisations The chances of duplicate payment are also less There is also a greater chance of detecting errors

In such cases one could perhaps say that this will result in 1% reduction in purchase cost Here it is more difficult to estimate the savings

Once the cost of the system and the estimated benefits are available then the project is evaluated like any other capi tal project The time tested and well known methods of

capital expenditure evaluation, like pay-back, discounted cash flow techniques etc. may be employed.

While for most of the applications the details of cost-benefit could be worked out, there would still be some exceptions, particularly where the benefits cannot be estimated accurately. So in planning systems where computerised techniques are used for simulation of forecasts, once the system is installed, a review should be undertaken with a view to ensure that the objective and benefits of the systems have bean realised. -This is known as systems audit.

Training

Training of personnel in data processing has always been considered as a very important function.

The training activity is required for 2 groups of personnel :

1. User groups.
2. Data processing personnel.

The user groups are again divided into :

1. Top management executives.
2. Senior and Middle Management level.
3. Operating and Junior Management level.

Most of the causes for failure in introduction of computer systems has been traced to lack of correct appreciation of the capabilities of the systems by the top management and user departments. Without the active support of the top management, successful introduction of computer system is not possible. Similarly, it is the user who is to use and run the system and not the data processing personnel. The early failures in the computer systems were mainly due to lack of appreciation of the capabilities of the system by the managers. Either too much was expected or too little. Managers were also afraid that the computers might snatch away their jobs. It is for this reason that the training and education of top management is most essential.

The second important point to remember is that the systems development costs in a computer system are quite high. Failure of the system developed could be quite expensive. The computer system requires a certain discipline to be maintained in feeding data. The system can sur-

vive only on user cooperation It is for this reason that user involvement from the beginning is very important This is achieved by intensive training of the user department on the system developed

In addition training of the Data Processing staff is also necessary With the changes frequently occurring in data processing technology it is only those organisations which keep pace with it which really can survive in competition Unless the knowledge of data processing personnel is constantly updated the management will have to live with out dated systems and lose in competition

The systems development cost should be treated like any other capital expenditure or deferred revenue expenditure for approval purposes Each system should be allotted a job cost and the cost should be accumulated for each system either periodically or on completion of the system Periodically a comparison should be made of estimated costs v/s actual costs This will not only help in cost control but will improve future estimates of cost Many organisations have introduced systems for control of costs even in areas like programming which was considered to be difficult to control as standards were difficult to be laid

Where major systems changes are involved or new systems are introduced it is advisable to have an independent committee to approve the system at each stage This will result in objectivity in laying down system priorities This will also ensure user participation at all stages of development and will facilitate faster implementation

Computer hire time vs own installation

At some stage or other every business organisation has to take a decision whether to have one s own facilities or to hire out time from outside computer installations

The advantages and disadvantages are discussed below

1 Costs The first and foremost consideration is financial Here the total operating costs of having one s own system is estimated and compared with the cost of obtaining the same services from outside

The costs are worked out in detail for each type of

activity, like the cost of getting cards punched within the company or outside. Such costs have to be worked out separately for each equipment. The advantage in this is that the costs in each category of activity can be compared. Secondly, costing of one's own jobs also becomes more accurate. For example, such a cost evaluation may disclose that the cost of computer application which uses the main CPU more, is likely to cost more than a purely printing job. even though both the jobs take the same time.

Once such a complete financial analysis is prepared, it would be easier to take a decision. This case is similar to a make or buy or a buy or lease decision.

2. **Security of data:** The other major factor to be considered relates to the security of data that is processed. If these are of a highly confidential nature, then obviously one's own installation offers better security than an outside installation. Modern computers, however, provide several privacy protection features.

3. **Flexibility:** One advantage of using an outside computer is the flexibility it offers. As improvements in computer technology take place, the most modern equipment could be made use of by shifting to a more sophisticated system. This will not be easy if the organisation is having its own computer. The cost of installing a new computer in the place of an old one could be quite formidable and may not be justifiable.

4. **Industrial relations:** Maintenance of one's own computer with a large number of operating staff, certainly adds to the industrial relations problem. This is to a large extent avoided by buying time from an outside computer.

Systems development costs

In the above discussion, the cost of systems development, programming and other software costs have been treated separately. The reason for this is that the software costs are quite independent of the hardware costs. Considerations as to whether to have one's own systems development staff or hire out the expertise, are different from considerations relating to hardware.

The basic factors that are to be reckoned are :

The systems development costs are increasing from year to year This is in contrast to hardware costs, which have been decreasing The reason is that with the increase in sophistication of systems, a considerable amount of systems planning requires to be carried out before a system is actually introduced In line with the system sophistication, programming efforts also increase in direct proportion With the development of packages and utilities for various standard system routines, it is now not necessary for each company to develop its own expertise These packages and utilities would cost only a fraction of what it would cost if one developed systems and programs oneself The range of software that are available is also very considerable In view of this fact, therefore it may not be economical to maintain specialist staff within one's own company except for large organisations

On the other hand the advantages of having one'a own staff are

1 The staff are more familiar with tha organisational raquiraments and are more likely to develop systams suited to the particular organisation with less time and affort

2 Systems and program changes and thair mainten ance are easy

3 One s own systems and programming staff may often cost lass than for employing outside specialists

4 Due to constant interaction with the hardware, programming staff and systems staff are more likely to exploit the capabilities of one s own computer

5 Better co ordination with users is likely thus contributing to greater success of the computer

All these factors need to be carefully considered before taking a final decision in this regard

18. EDP Controls and Audit

One of the major advantages under a manual system is that it facilitates checking of data processing steps as and when one operation is completed. For example, under the manual system of maintaining stores accounts, each item of receipt and issue is posted in the Stores Ledger. The values are also indicated against each item. The individual values of receipts and issues are available. The closing balance is then taken and final value advised. At the end of each of these steps, the results can be verified manually with reference to the original document. In a computer system the quantities of stores receipts and issues are punched onto cards. Similarly, the values are also indicated. The program is fed into the computer and a statement of closing stock value is arrived at. The final value could be one total. Here, if one wants to verify the final total, the printouts of detailed calculations have to be obtained at the end of every step. This will increase the computer processing time. Without these printouts, it will be difficult to audit the output. This is the problem faced by the Auditor who has to certify the same. This chapter deals with this aspect of the problem.

In order to ensure the accuracy and reliability of the final output, one should critically examine the areas where the operations could go wrong resulting in inaccurate output. Then one could build up controls for detection and rectification. The entire control activity for this purpose can be logically grouped into five categories :

1 Control over data preparation
2 Control over data input to the computer
3 Control over the program logic
4 Control over processing
5 Control over the output distribution

The control should naturally correspond to tha mistakes or failures that are likely to occur in tha system These are briefly Indicated below

1 Incomplete receipt of data
2 Wrong coding of data
3 Punching errors
4 Program logic errors
5 Machine failures
6 Distribution of incorrect output

The controls that are required to be established are discussad below in detail

1 Control of data preparation

Most of the errors in data preparation are reducad by proper training of staff in charge of coding at locations where data processing originates The coding structura should be aimple and briaf

2 Data validation and Input control

It is obvious that the final output can be only es accurate as the input data It is therefore necessary to organise the data input in such a manner that before the data is keyed into the computer the accuracy s established This is made possible by a variety of controls Some of these are discussed below

(i) Serial ccntrol In order to ensure that all documents are duly received before processing it Is necessary to have a serial number control Thls will enable tha Section to call for any missing document before the processing takes place This is particularly necessary in a batch mode processing

(ii) Document movement control Whenever documents are moved from one machine or operation to another it is necessary to route it with transmittal slip indicating tha number of documents

(iii) **Control total:** Whenever the documents are to be processed either for punching a verification or for tabulation, it is advisable to take a total of the key value of the documents in the batch. In Sales Accounting, for example, the total invoiced quantity of all supplies in a batch should be first taken and then this total can be checked with the final total. This will essure that all documents have been correctly processed.

(iv) **Code check:** It may be advisable to have a partial checking of codes manually to test the accuracy of the codes. This is necessary whenever new codes are introduced or changes made. Pre-printed codes and use of Bradma plates will also eliminate ccding errors. There should also be a cell to allot new codes. It is frequently noticed that lack of control on allotment of new codes and changes in the coding structure has often led to errors.

3. Machine checks

(i) **Check digit:** In addition to mechanical aids and manual checks for control, it is advisable to use the check digit system to detect coding errors by the computer. Check digit is an additional digit provided for automatic check on the code. This establishes the correctness of the code. The check digit is arrived at in the following manner. If a customer code is 432 then all the digits are added till a final number is arrived at. In this case 4+3+2=9. The number is then added to 432 making it 4329. In other words, the number 432 always carries a check digit 9. Any error in the number is automatically checked by the computer.

(ii) **Control over programme logic and processing:** Errors may arise while processing due to two reasons. One is logical error which could not be detected or thrown out at the time of testing the program. The other is the accidental loss during movement of the data within the computer. To discover this, additional controls are built in. These are in addition to the parity check and check digit control mentioned earlier. The parity bit concept has been explained earlier in Chapter 11.

(iii) **Cross footing test:** This is very similar to the controls built in the manual system. The usual example given

is the case of pay roll where separate totals are made for gross pay as well as each type of deduction The net pay calculated employee wise is totalled and checked with gross pay less gross value of each type of deduction This will throw out mistakes if any in processing the data

(iv) **Limit or reasonable test** By specifying the upper limit and lower limit of a data item the computer will automatically throw out cases where these limits are exceeded For example by specifying the highest possible take home pay any error which results in a higher take home pay than the limit provided is thrown out while pro cessing the data

(v) **Combination checks** These checks are introduc ed for checking the appropriateness of the data in a variety of weys for use Numeric fields may be tested to ensura that there are no alphabetic numbers

(vi) **Sign checks** These checks ensure that belances with the wrong sign (+ or −) do not appear in a field not expected to contain this This is particularly necessary while processing financial accounting instructions

(vii) **Control on key entry** In case of key entry where data is directly transmitted to the computer or storege medium data is validated in a mini computer system before allowing it to ba entered into tha main storage medium

4 **Output control**

Before any output is released it should be ensured that all controls built in for ensuring the accuracy and comple teness of the output are carried out In addition it is neces sary to obtain feedback from users on tha correctness of data For example in the case of Provident Fund balance or Housing Loan advance the recipient should be asked to certify the correctness It is also important to have a pro per control over the output distribution so that incomplete and inaccurate outputs are not circulated

EDP and Audit

It is the role of the Auditor to satisfy himself that the in formation coming out of the computer is accurate and valid In a manual system well developed and time tested control

systems operate. The exact operation of controls at different stages can be checked as the manual system leaves a sufficient trail for the Auditor to follow. This is not always provided in a computer system. Nevertheless, during the last few years the following practices have been built in to facilitate Audit trail :

1. Before any system is put into operation, the adequacy of control is certified by the Company's Auditors, internal or external.

2. All systems and procedures are well documented. Control is maintained not only on the original system but subsequent changes. For example, all alterations in programs are duly authorised and a complete record of changes is maintained.

3. The systems and programming responsibility is segregated. Similarly, the programming and operating staff are kept separate.

4. All documents under EDP control are classified as confidential and access to them limited.

5. Proper record of the transmittal documents like control slips, etc. are preserved and available to audit for a test check.

It is advisable for the Auditors to have their own staff of experts to test check the programmes with actual or test data to make sure that logical errors do not exist which would vitiate the accuracy of the final result.

Control through EDP

In large organisations the manual systems have failed to provide the control necessary to ensure the financial interest of the organisation is properly safeguarded. Proper internal checks for detection of errors and prevention of fraud have always been recognized as an important tool of internal control. Consequently in many organisations increasing use is being made of the capabilities of computers in this area. Typical is the case of large organisations where computers are used for:—

1. Checking of rates in invoices.
2. Bank reconciliation.
3. Checking of transport contractors' bills.

4 Reconciliation of customers' accounts with sales records etc

The advantage in using the computer system lies in the fact that a large number of items can be checked in a comparatively shorter time This results in a quicker location and rectification of errors as compared to the manual system The checking also tends to be more accurate

The capabilities of computers have also been used by internal audit and external audit for various sample or test checks to test the efficacy of a system In fact several audit firms have developed their own audit programmes for checking the accuracy of clients' records This apart from reducing the Audit time has resulted in a more efficient audit

19. Data Security

The data that is stored in a computer system has to be protected against misuse. In the absence of proper protection features the data can be manipulated resulting in loss to the organisation. Similarly, the information contained can be misused to the detriment of the organisation. The problem of manipulation of data and misuse of data has reached alarming proportions in western countries and one frequently hears several organisations having to wind up their business on account of computer frauds.

It is, therefore, necessary that every organisation develops procedures inside and outside the computer environment for security of the data against misuse and protection of the information.

The possibility of mistakes occurring due to computer errors and the various steps required for control of the same have already been discussed. These steps are necessary to ensure the accuracy of the data. But this does not take into consideration the possibility of deliberate tampering of the data, or misuse of data for personnel ends.

Based on the experience gained in operating computer systems, many organisations have now developed controls for security. Some of these controls are given below as illustrations.

Control over physical access to facilities and personnel

1. The access to the computer has to be restricted only to the essential operating and maintenance staff. All

operations in the computer room are continuously monitor ed by a senior supervisor

2 The computer installation is well protected and entry is only permitted on proper authorisation Normally entry to outsiders is d scouraged

3 Proper physical control is maintained on all equip ments and storage devices Access is limited only to those who have to handle and operate the equipment

4 Confidential personnel records are thoroughly scruti nised before selection of computer personnel so that a per son with doubtful integrity or character is avbided

Work allocation

5 The work of programmers systems analysts and operating people are kept separate Under no circum stances should a programmer ba allowed to operate a com puter and vice versa

6 A programme developad has to be authorised at more than one level before putt ng it into usa Similarly all changes and modificatcns of routines hava to have proper authorisat on

7 Systems flowcharts manuals programmes relating to a particular system etc are all classified as confidential and stored carefu ly under lock and kay Under no circum stances shall operating persons have access to them It is advisable to store these documents in parts separately so that a complete picture at one place is not available

Machine controls

1 Careful consideration should be given at the time of selection of equipment to ensure that special protection features are ava lable in the hardware for protection and accuracy of data

2 Under no circumstances should a situation arise where data in a file or storage is intentionally or accidentally destroyed Duplication or reconstruction is usually not possible

The above po nts are only illustrative of some of the aspects involved Security has to be given a high priority consideration and is an essential part of data processing man agement

APPENDICES

1. Systems Analysis Checklist

The following checklist will enable the Systems Analyst to be sure that nothing has been overlooked.

A. REQUEST FOR INVESTIGATION

The Analyst must know—

* The Manager responsible for the system being investigated.
* All the other Managers involved.
* The exact scope and objectives of the investigation.
* Whether there are any new objectives.
* The reasons for the investigations.
* The time and money available.

B. PLAN OF ACTION

The Analyst must find out—

* The organisational set up of the departments.
* What precisely are the functions, duties and responsibilities of all the departments concerned?
* Who are the managers, supervisors and staff?
* Whether any previous studies were made and if so, what are they?
* What recommendations were made and which of these were implemented and which not, and why?

The Analyst must plan his activities and estimate their respective durations.

C. FEASIBILITY STUDY

* Has the problem been identified and defined?
* Has the detailed information needed about inputs, outputs and files been obtained especially in regard to medium, frequency, times required or available, volumes and purposes?
* Why is the data produced/received/processed or retained?

* What is the source and what is the destination?
* What are the limits and constraints within which the system must operate?
* Have the exact allocations of responsibilities been clearly understood?
* Has the system been assessed in terms of accuracy, reliability and capacity for development and expansion?

D REPORT TO MANAGEMENT

Has the Analyst—

* Indicated the feasibility and cost benefit?
* Substantiated his findings by detailed and accurate data?
* Stated *the resources to be used limitations, constraints* accuracy or any other special problems?
* Made firm recommendations with adequate justification?

E DETAILED STUDY

1 Preparation for the interview

* Has the study been well planned?
* Has the department been fully prepared for the investigation and does everyone concerned know about it?
* Has the Analyst carefully considered beforehand all the questions he is likely to ask during the interview?
* Has the interviewee s immediete superior been consultad end kept fully in the picture?

2 Recording facts

* Has the information gathered during the interview been carefully recorded?
* Is it consistent within itself and with other information gathered from other interviews or from elsewhere?
* Has the interviewer checked the record and found it satisfactory?
* Has it been ensured that the Analyst has actually observed the work instead of merely accepting what has been told to him?
* Has the Analyst kept a record of important points or facts gathered from informal chats or discussions?

3 Documenting

* Has a specimen copy of all the relevant documents been collected?
* Has the origin and purpose of all the items been noted?
* Are the nature, quantum and reasons for the exceptions known?
* Have all the detailed processes of the systems been ascertained and recorded?

* Have all the procedures for checking been considered?
* Have the facts gathered and recorded been checked and confirmed for accuracy with the departments concerned and other departments involved?

F. DEFINING REQUIREMENTS

1. Assessment of system
   * Is the Analyst clear that the criteria by which the assessment of the system has been made are in accordance with those laid down in the terms of reference?
   * Has a review of the system been carried out in respect of time, cost, other constraints, convenience, vulnerability, effectiveness and performance against standards?
2. Statement of requirements
   * Does each item satisfy a demand?
   * Has each item in the requirements a defined source?
   * Have all the requirements been formally specified as to form and derivation?
   * Has each requirement been examined to see if the presentation could be improved to make it more useful or familiar to the user?
   * Has Management approval been obtained for all the requirements?

G. SYSTEM DESIGN AND SPECIFICATION

1. Evaluating the system

   Has the system been evaluated in terms of—
   * The cost of installing the system?
   * The cost of operating the system?
   * Its reliability?
   * The accuracy which can be achieved?
   * Security?
   * Control?
   * Flexibility?
   * Capacity?
2. Reporting to management
   * Is the report in conformity with the terms of reference?
   * Does it give a simple description of the system without much use of technical terms and jargon?
   * Does it include estimates of the relative effects on the business?
   * Does it set out the costs of implementation, operation, redeployment of staff who may become redundant, training of the staff necessary for operating the system, and new capital equipment which may be necessary?

* Is allocation of responsibilities for the new system been properly specified?
* Is the date of implementation included?
* Have the financial implications relating to the site equipment staff the training required by them and the cost of stationery furniture etc been estimated?

H ACCURACY AND SECURITY

* Is all data checked for accuracy and security?
* Is there proper control on error rejections?
* Have the files been updated correctly?
* Can results be shown to be complete?
* Have the auditors agreed to the system?
* Have restart facilities been incorporated?
* Have all transcription procedures been covered?
* Have arrangements been made to protect documents in storage transit and use?
* Will old data and files be retained for reconstruction purposes?
* Has the transport of data been properly timed?
* Are there standby arrangements for transportation of data?

I FILE STRUCTURE

* Will there be benefits in splitting a file between frequently and rarely used records or parts of records?
* Are different groups on the file processed at different times and if so has advantage been taken of this?

J GENERAL SUITABILITY AND COMPATIBILITY

* Will computer time always be available at the required time?
* Will the results be available at the time needed?
* Are the users put to any inconvenience as a result of the demands of data submission?
* Has allowance been made for the effect the system will have on other parts of the business in respect of duplication of work increase or decrease of workload changes in timing of work and changes in information?
* Have all input output and files been completely specified?
* Can all the output be derived from the given input and files?
* Have calculations of timings been allowed for peak periods?
* Can the file expand without unacceptable increases in processing time?

K IMPLEMENTATION

1 File conversion

* Has it been ensured that the file conversion will not impede other routine work in the user department or the data preparation department?

* Have proper instructions been given to clerks on file conversion?
* Are all required forms ready?
d Have arrangements been made to allow the auditors access to the converted files, or such results as they require?

2. Training
   * Have all the points at which the system affects the user been considered with training in mind?
   * Have the appropriate training personnel or training organisations been consulted?
   * Has the department management been consulted?
   * Has training been properly planned and opportunities for practice provided?
3. Manuals
   * Has the manual been checked for accuracy and intelligibility by non-technical staff?
   * Have all data and results been covered?
   * Have error reports and validity checks been covered?
   * Have the timings of the system been validated and agreed?
   * Have standby arrangements been described?
   * Have all exceptional, occasional and periodic procedures been included?

2. Forms used in Systems Analysis

(See Chapter 3)

The formats of the forms usually used in Systems Analysis have been reproduced in this Appendix The manner in which the forms are to be filled up is given below

FORM 1—DECISION TABLE FORM

This form is meant for specifying procedures by means of Decision Tables The form is large enough to contain most tables and in case they cannot be accommodated in the form it could probably be handled more conveniently if they are broken down into two or more tables In general 3 or 4 conditions are likely to form an optimum size of table though of course much larger ones can be handled without using the *or else* rule

The heading Relative Frequency is the percentage occurrence of any one rule *This is used for guidance in Programme Planning*

The other headings are self explanatory

This form is part of the systems documentation and should be given a reference with cross references to other documents

FORM 2—OUTPUT ANALYSIS CHART

An Output Analysis Chart is necessary to facilitate analysis of documents in terms of their contents The technique may be used both in the Analysis phase to determine the requirements of the system by showing what information is necessary in records and source documents as also in the Design phase to show how this information may be usefully presented The chart also indicates points in the reports where duplication is likely to occur and can be utilised to find out what reports can be eliminated or reduced in the information content and whether some of them can be usefully combined The chart would also reveal unnecessary or redundant information

The documents are listed on the left hand side of the chart together with a note of their frequency. All elements of data that appear on any report are listed along the top of the form. An appropriate code is then marked where rows and columns intersect to show which information will compare on which report.

FORM 3—OPERATION SUMMARY FORM

Organisation : The name of the department for which the study is being conducted.

System : The name of the system which is being reviewed

Operation : The name or a brief description of what is being done by the interviewee.

Interviewee : Name of the person who is being interviewed.

Operation Purpose : Why is the operation being performed and whether it fulfills the intended purpose. Brief details should be given in this column.

Documents/Data In

Name : The name of each document or set of data is recorded. If the input is a form, the form reference number is given.

D S F Reference : Reference to the Document Specification Form (Form 4). The reference number of the form on which the input document is described in detail should be entered here.

From : The name of the department or the person from which the information is received.

Frequency : For example, daily, hourly, monthly, etc. When the information is received.

Quantity : For example, in terms of maximum, average, minimum, number per period indicated in the frequency column.

Validated : In case information obtained should be cross-checked, either by observation or by verifying it from other sources this column should be tick marked.

Results Out : Record the results such as reports produced by the interviewee.

Files kept and/or referred to

Description : Name of the file maintained or references, e.g., stock card.

F S F Reference : This has reference to the File Specification Form (Form 6) in which the file has been described in detail.

Average No. of Records : The average size of the file.

Used for : Brief notes of the purposes for which the file is maintained or referred to.

Medium The medium on which the file is held

Processes carried out Brief notes of the main activities performed e g sending out statements

FORM 4—DOCUMENT SPECIFICATION FORM

The following are the details of the columns which are included in the form —

Title & Form No This refers to the name of the document or form If it has a form no specify it

Input/Output/File Delete whichever is not applicable

Method Whether it is filled by hand by Bradma machine by typewriter etc

No of copies This has reference to the number of cards including the original or first copy when the document is a multi part set

Frequency Whether it is daily weekly fortnightly monthly etc

Sequence When more than one copy is preparad in what order are they produced For example customer accounts may be produced in Account No order alphabetical order, sales areawise order etc

Volume The quantity of documents prepared in one cycle of operations i e during the period mentioned under frequency

Sent to This refers to the department which receives the form

Used for The purposes for which the Receiving Department uses its copy of the document

Source The files or other data used in preparing the document If there are different sources the relevant items involved should be specified Where a source document is described on another Document Specification Form the reference number of that form should be quoted

Special Requirements Certain documents have special requirements in regard to size or contents For example outside organisations such as banks may impose such conditions These requirements should be specified If particular wordings are required they can be indicated on the Specification Form which should always be attached and referred to in these columns

Refer to forms If references are made to other documents the names of such forms should be entered here

Specimen attached. A tick mark in this column indicates that a copy of the form is attached

FORM 5—CONTENTS FORM

The following are the details of the columns which are included in the form —

Name & Reference: Here write the name of the document which is being described and the relevant Document Specification Form

No. & Item identifier. Each item is numbered and described for purposes of reference

Size: It is necessary to know how many characters there are in an item If the number varies, the minimum and maximum limits should be stated, as these figures will later influence the file design For example—

Number	Identifier	Size
6	Type	7
7	Type size	3 to 12
8	Value	5 to 10

These figures are used along with the picture statement and, therefore, must include all punctuations and other symbols For instance, in the above example, the maximum of 10 characters under Item 8 could represent a maximum possible value of Rs 999999 99 for this item

Picture · The object of this function is to give the format layout of the information in question It is used along with the size, and if the size is variable, the picture is always given for maximum characters The conventions used in this statement are

A = alphabetical character

X = alphanumerical

9 = decimal character

S = mathematical sign

FORM 6—FILE SPECIFICATION FORM

The following are the details of the columns which are included in the form

File Name: The name by which the file is commonly known

Record kept for each. This refers to employee, customer, stock items, etc.

Sequence: The order in which the file is maintained If it is numerical order, further details should be given, e g, productwise, customerwise, etc

Medium: For example, loose leaf binders or kardex system

No. of Records: The average size or volume of the file

Location: The department where the current file is kept.

Details on Form Ref C This refers to the relevant Contents Form (Form No 5)

Documents used for amendments The names and Document Specification Form reference of any documents from which amendment information is derived

New Records

Authorised by Designation of the person who has authorised additions to the files

Frequency How frequently are the additions made

Volume The volume of such new records

Current file The details are entered as to how long a file is retained as current and under what circumstances it becomes dead ie no longer maintained or used for day to day work

Dead file When the dead files are transferred to archives but can still be used for historical or statistical information details should be given here

FORM 7—PROCESSES FORM

The following are the details of the columns which are included in the form

Organisation Refers to the department to which the study is being conducted

System The name of the system which is being reviewed

Type The method of carrying out the procedure viz manual punched card etc

Referred to in The reference numbers of forms such as Contents Form which refer to the process described on this form

No A serial no which together with the reference no of this form enables the process to be identified in a unique manner

Function The function performed should be described by verbs such as CHECK REFER SORT UPDATE VERIFY PUNCH ENTER READ etc

Description A brief narrative description of the function

FORM 8—STATEMENT OF REQUIREMENTS FORM

The following are the details of the columns which are included in the form

Organisation The name of the project undertaken

Identity The name of the particular aspect of the project being studied e g invoicing stock report customer ledger, etc

Condition The condition that gives rise to the production results has to be stated here The statement generally takes the form FOR

EACH.....When, for example, for each customer's account when a matching order has been received.

Sequence: The general form of its entry is "item identifier" WITHIN "item identifier".....ORDER. The sequence may be stated as "immaterial", for example, print out of invalid records from basic input data.

Frequency: The required frequency of production of the result, e.g., daily, monthly, etc.

Time: Any requirements for the result to be available by a certain period, e.g., before 1.00 p.m. on Fridays, is stated here.

Distribution: Designations of the people who should receive the output.

Priority: If logical or business considerations dictate the production of this result before, or after, other specified jobs, or this job has priority over all other jobs, this should be noted down.

Volume: The number of this type of result to be produced. The absolute number, if appropriate, or minimum, maximum and average numbers.

Item Code No.: To facilitate reference, each item may be given a code number.

Identifier: The name and description of the item.

Level: A number is used to show the hierarchical relationship of the items within the form. For example,

Identifier	Level
Customer details	2
Name	3
Initials	4
Surname	4
Address	3
Street	4
Town	4
State	4

Picture: The size, type and format of the item expressed.

Occurrence: If any item or item group is repeated within a record, an entry is made to define the number of times it occurs. If this number is variable it is stated as minimum, maximum or average numbers. If it is fixed, the appropriate figure should be given as an absolute number.

Derivation or notes: This column is used to describe the origin of the item and to specify any calculation that may be performed to produce it.

FORM 9—FILE DESCRIPTION FORM

The purpose of this form is to give an overall description of a file This form will be supported by one or more sheets describing in detail the records and the items that make up the file Some of the columns are described below

Version All files that contain the same information but of which the records are arranged in different sections e g invoicing movements sorted successively to customer number to update the debtors file the commodity code to update stocks and area code for sales statistics are all recorded as different versions of the same file They will have the same file code with a different suffix The use of this system reduces the necessity to repeat detailed descriptions of the file

Sequence produced The usual form of this entry is item identifier WITHIN item identifier ORDER The sequence may be stated as IMMATERIAL e g the raw input data or RANDOM when the file is held in true random order If there is only one item in the file the entry ONE ONLY is made

Medium The medium on which the file is held e g magnetic tape punched cards etc

Type Here specify whether this is an input output or reference file A reference file is one which is updated in the system or otherwise referred to

Priority This relates to the production of the file i e before job X or before 15 hours on Friday

No of copies This refers to computer files output for the benefit of the printer

Size of file The size of the file is expressed in terms of the number of records it contains When this is variable the minimum maximum or average sizes are given

Received from/sent to The source of the data by department or function name is entered here in the case of input files For output files the total or function of the recipient of each copy if more than one is produced is noted

Frequency produced For an output file it is necessary to specify whether the file is to be produced daily weekly etc

Retention period The period for which the file is to be retained as current

Condition The condition that gives rise to the production of the results is stated

FORM 10—LIST OF FILE ITEMS FORM

The purpose of this form is to describe in detail the records

which constitute the file. A separate form should be made out for each type of record comprising the file.

Identity: The name of the record or of the item group or item is recorded here.

Level: This is the same as in Form 8.

Picture: In this column the format of the data comprising the item is given.

Occurrence: When any item or item group is repeated within a record, an entry is made to define the number of occurrences. When this number is variable, it is stated as minimum, maximum and average number.

Y Reference: This refers to Form 11.

FORM 11—DERIVATION OF FILE ITEMS FORM

The means of arriving at the value of an item is described here. For example, there may be several prices for each item in a Master *Commodity file. The price to be charged for a particular commodity* may be determined by a digit of the purchases code number indicating whether he is a wholeseller or a retailer.

Sequence and condition: If an item or group appears several times within a record, the year in which the successive groups are arranged is stated here.

Associated items: The code numbers of the record or item and file containing information used in the calculation of the item described may be included together with the reference number of the List of File Items forms on which that item is described.

FORM 1

DECISION TABLE

Project | Reference | Author | Date

Table name

Number of conditions	Number of actions	Number of rules

Rule numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Else
Relative frequency (%)																	
No Conditions																	
No Actions																	

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Forms 1 to 11 Courtesy International Computers (India) Private Limited

FORM 2

OUTPUT ANALYSIS CHART

COMPANY Bharat Pipes Ltd DATE 16 Mar, 1978

PROJECT 132/78 COMPILED BY P.S. Nath

Data Fields

*N=Numeric
A=Alpha
A/N=Alpha/Numeric

Frequency			Customer No	Traveller	Branch	Name & Add (Invoice)	Name & Add Consignee	Date	Order No	Cost No	Item Description	Qty Ordered	Price	Extensions	Purchase Tax	Cash Disc	Gross	Net	Credit Limit	Current A/C Bal	1 Month A/C Details	Trav Sales Mnthly Value	Branch Sales
	Field Type A N or A/N*		N	N	N	A/N	A/N	N	N	N	A	N	N	N	N	N	N	N	N	N	N	N	N
	Field Size in Characters	Max	5	2	3	66	80	6	8	6	8	6	6	8	5	5	9	9	5	9	80	9	10
		Average	5	2	3	58	50	6	5	4	4	4	4	5	4	4	6	6	5	6	36	6	7
	Output Documents																						
D	INVOICES		R	R	R	R	S	C	S	R	R	S	R	C	C	C	C	C					
D	CREDIT CONTROL REPORTS		R	R	R			C											R	R	R		
D	A/C QUERIES		R	R	R	R		C											R	R	R		
M	STATEMENS		R	R	R	R		C												R	R		
M	TRADE REPORTS (A)				R			C		R		R											
M	CREDIT STANDING REPORT				R			C												R			
A/Q	PRICE CHANGES AND OTHER NOTICES		R	R	R	R		C				LETTER/FORM			NARRATIVE		PLUS NEW PRICES CHANGE OF E/T ETC						
M	TRADE REPORTS (B)		R	R	R			C						C		C							
M	COMMISSION TAB.			R	R					R		R		R								C	C
Q	QUARTERLY ABSTRACT				R																	C	C

R=Record S=Source C=Calculated

FORM 3

OPERATION SUMMARY

Organisation | System

Operation | Interviewee

Operation purpose

Documents/data in

Name	DSF ref	From	Freq	Max	Min	Avge	Abs	Validated

Results out

Name	DSF ref	To	Freq	Max	Min	Avge	Abs	Validated

Files kept and/or referred to

Description	FSF ref	Average no of records	Used for	

Processes carried out

FORM 4

DOCUMENT SPECIFICATION

Title

Form no Input/Output/File

Prepared by

Method No of copies

Frequency Sequence Volume

Sent to Used for

Source

Special requirements

Refer to forms Specimen attached

FORM 5

CONTENTS

Name DSF ref

No	Item identifier	Size	Picture	Range checks notes, etc

FORM 6

FILE SPECIFICATION

File Name

Record kept for each

Sequence Medium No. of records

Location

Contents Details on form Ref. C

Documents used for amendments :

Name	A ref.	P ref.	Name	A ref	P ref.

New records

Authorised by

Frequency Volume

Current file Period kept

Condition for transfer to dead file

Used by	For	O ref.

Dead file Period kept Location

Reasons for retention

Used by	For	O ref.

FORM 7

PROCESSES

Organisation

System Type

Referred to in

No.	Function	Description

FORM 8

STATEMENT OF REQUIREMENTS

Organisation

Project

Identity

Condition

Sequence

Frequency.

Time

Distribution

Priority

Volume Min. Max. Avg/Abs

Occurences

Item Code No.	Identifier	Level	Picture	Min.	Max.	Avg/Abs *	Derivation or notes

* Delete as appropriate

FORM 9

FILE DESCRIPTION

Organisation	
Project name	Project Code
Identity	Code

Version	Sequence produced	Medium

Type		Priority		No of copies
Size of file	Min.	Max	* Avg Abs	Received from/sent to
Frequency Produced		Retention		
Condition				

* Delete as appropriate

Page of

FORM 10

LIST OF FILE ITEMS

Organisation

Project | Project Code

Identity | Code

Item Code No.	Identifier	Level	Picture	Occurrences Min.	Occurrences Max.	Occurrences Avg/Abs *	Y Ref.	Notes

* Delete as appropriate

Page of

FORM 11

DERIVATION OF FILE ITEMS

Organisation

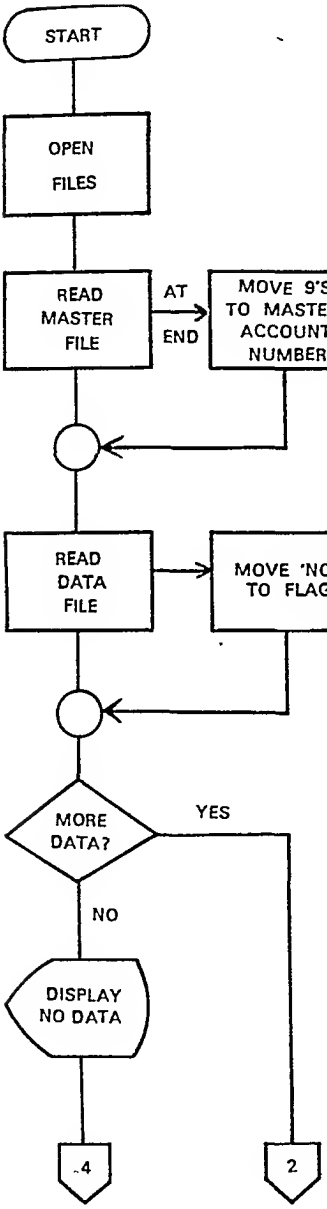
Project | Project Code

Identity | Code

Item code no	Origin or method of calculation	Associated items: Sequence & condition	Item code	File code	X Ref	Notes

Page of

3. Program Flowchart



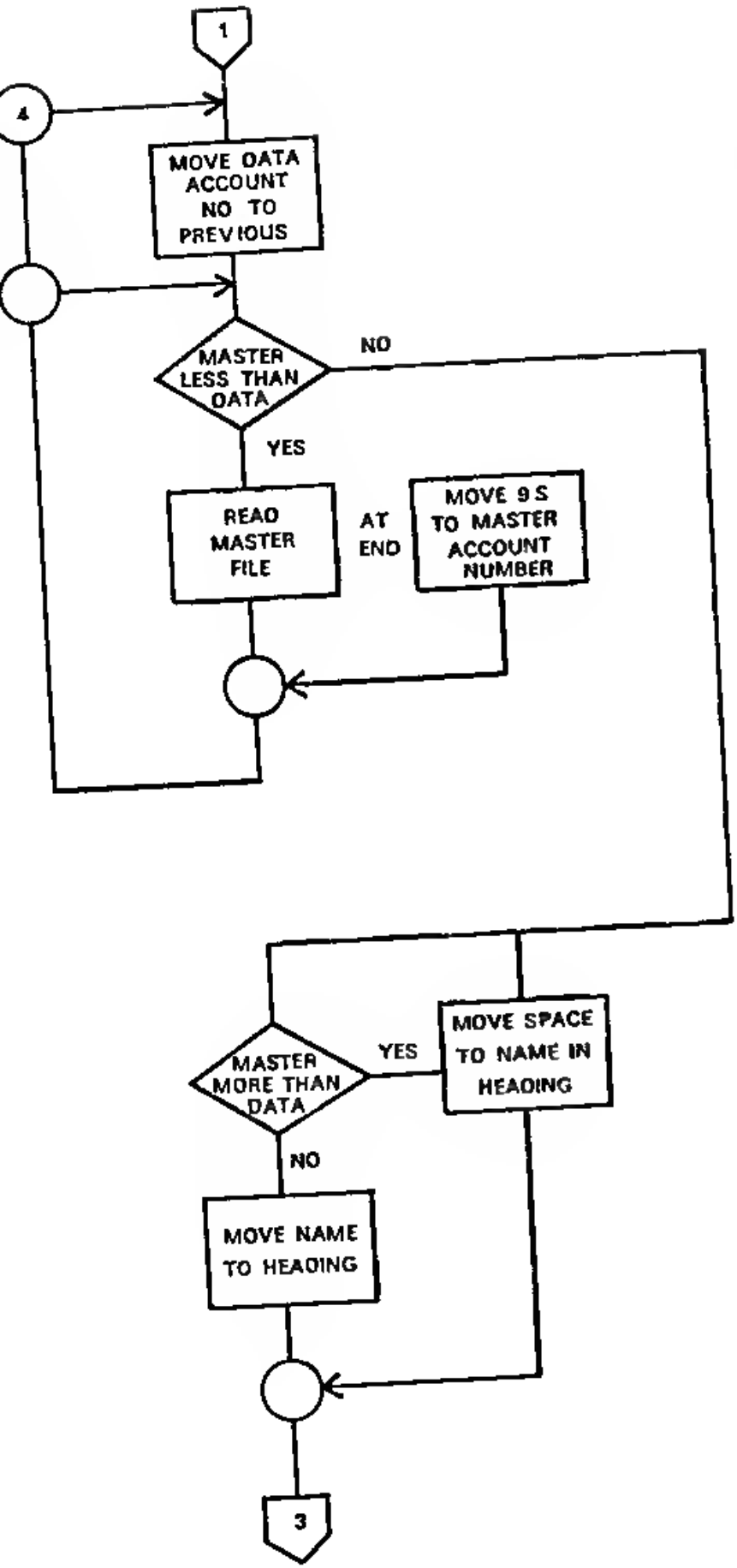
005 — 080

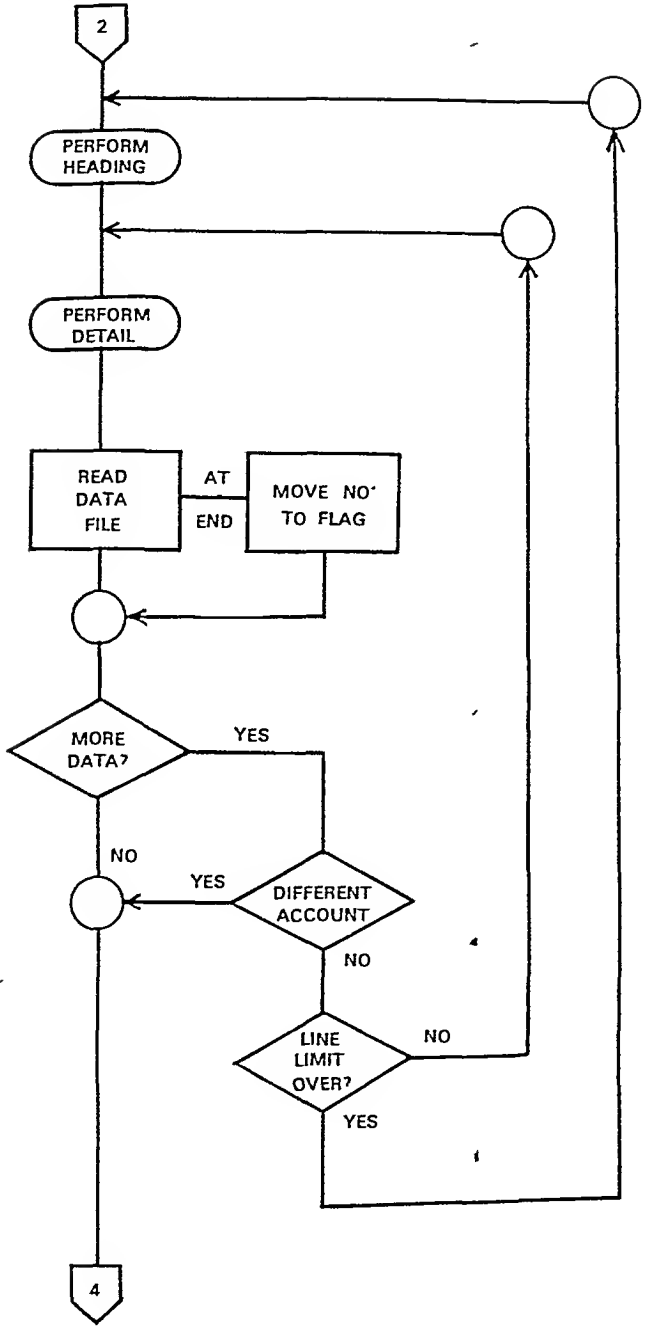
005 — 090

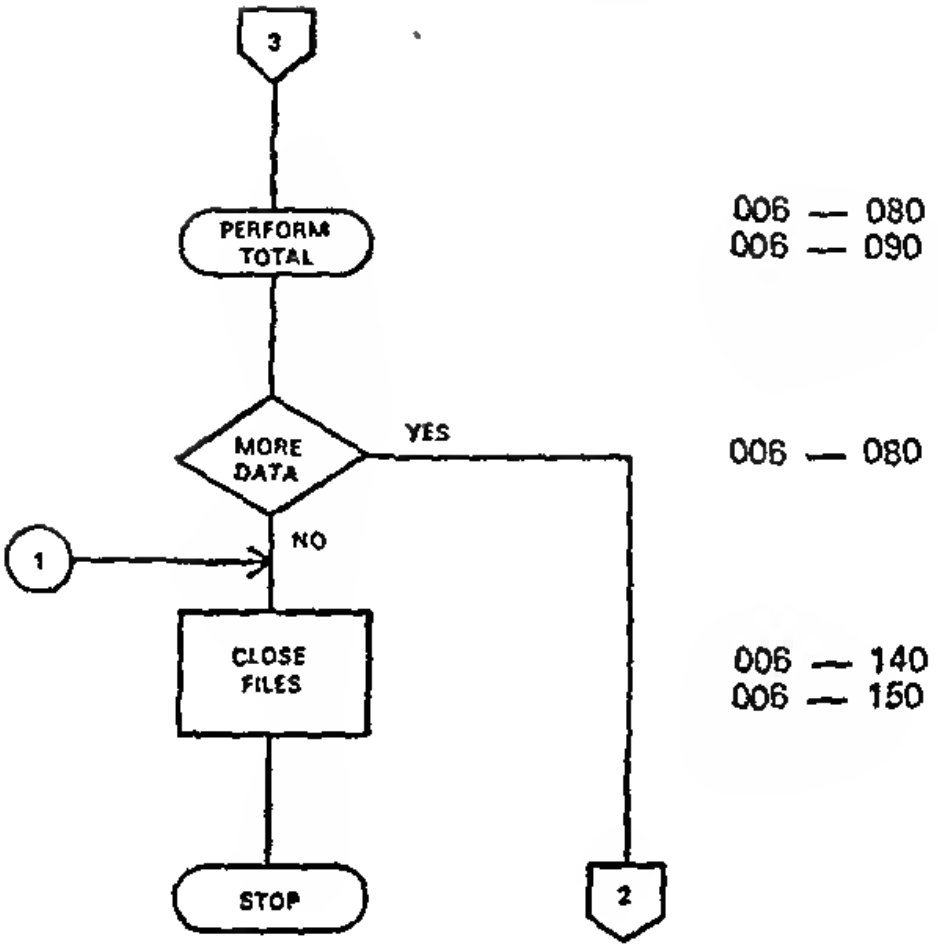
005 — 100

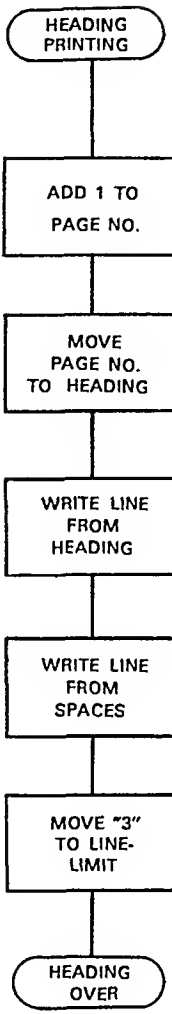
005 — 110

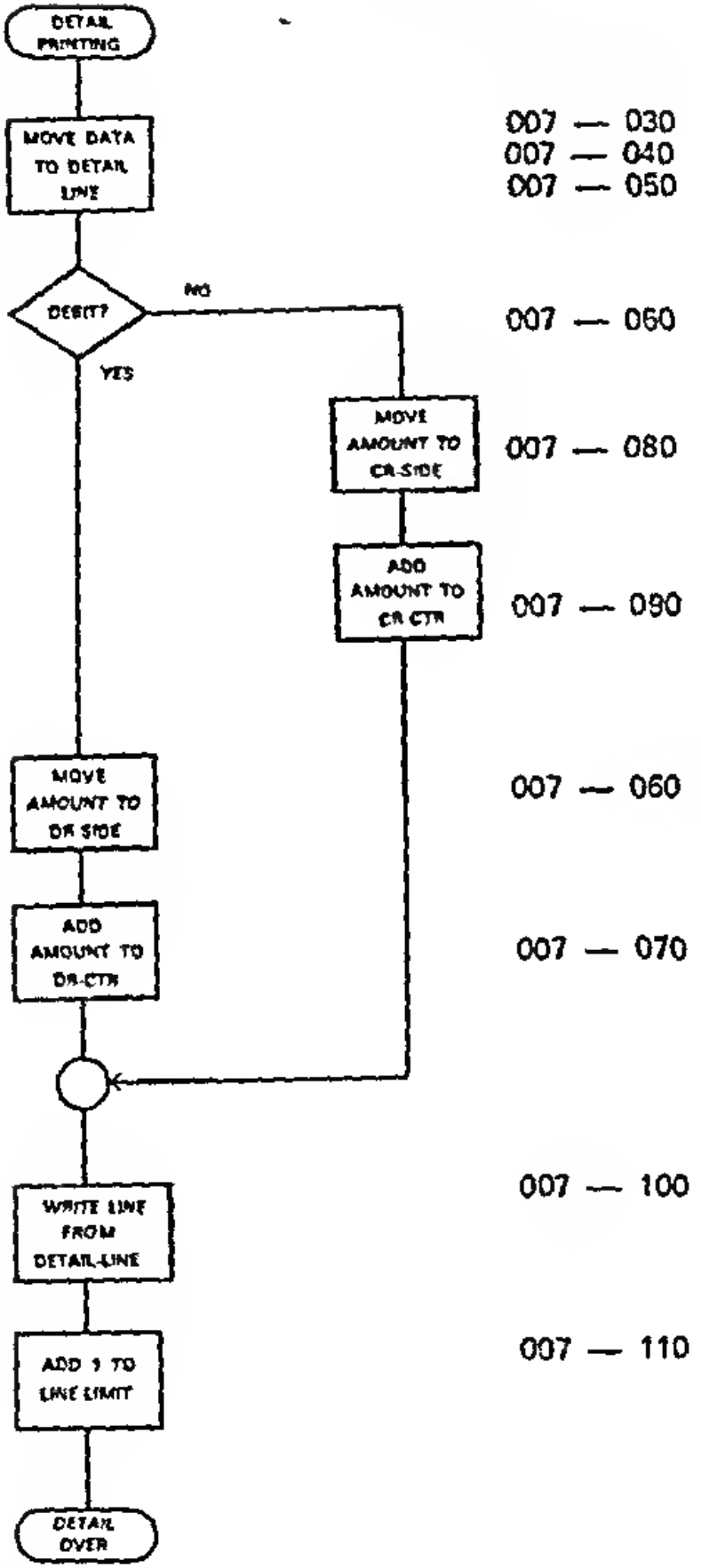
005 — 110

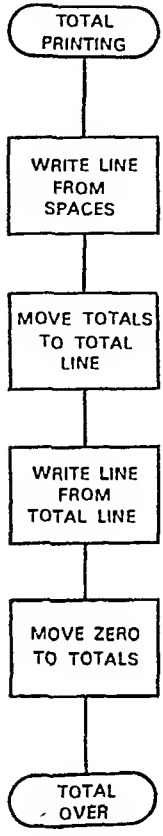

1
4
MOVE DATA ACCOUNT NO TO PREVIOUS
005 — 140
005 — 160
MASTER LESS THAN DATA
NO
YES
READ MASTER FILE
AT END
MOVE 9 S TO MASTER ACCOUNT NUMBER
005 — 180
MASTER MORE THAN DATA
YES
MOVE SPACE TO NAME IN HEADING
006 — 010
NO
MOVE NAME TO HEADING
006 — 020
3


2
PERFORM HEADING
006 — 040
PERFORM DETAIL
006 — 060
READ DATA FILE
AT END
MOVE 'NO' TO FLAG
006 — 070
MORE DATA?
YES
006 — 080
NO
YES
DIFFERENT ACCOUNT
006 — 090
NO
LINE LIMIT OVER?
NO
006 — 110
YES
4


3
PERFORM TOTAL
MORE DATA
YES
NO
1
CLOSE FILES
STOP
2
006 — 080
006 — 090
006 — 080
006 — 140
006 — 150


HEADING PRINTING
ADD 1 TO PAGE NO.
006 — 170
MOVE PAGE NO. TO HEADING
006 — 180
WRITE LINE FROM HEADING
006 — 190
WRITE LINE FROM SPACES
006 — 200
MOVE "3" TO LINE-LIMIT
007 — 010
HEADING OVER


DETAIL PRINTING
MOVE DATA TO DETAIL LINE
007 — 030
007 — 040
007 — 050
DEBIT?
NO
YES
007 — 060
MOVE AMOUNT TO CR-SIDE
007 — 080
ADD AMOUNT TO CR CTR
007 — 090
MOVE AMOUNT TO DR SIDE
007 — 060
ADD AMOUNT TO DR-CTR
007 — 070
WRITE LINE FROM DETAIL-LINE
007 — 100
ADD 1 TO LINE LIMIT
007 — 110
DETAIL OVER


TOTAL PRINTING
WRITE LINE FROM SPACES
007 — 130
MOVE TOTALS TO TOTAL LINE
007 — 140
WRITE LINE FROM TOTAL LINE
MOVE ZERO TO TOTALS
007 — 160
TOTAL OVER

4. Cobol Program Sheet

PROGRAM-ACCOUNTS RECEIVABLE

SEQUENCE (Page) Serial 1 3	4 6	CONT 7	A 8	B 12
0 0 1	0 1 0		IDEN	TIFICATION DIVISION
0 0 1	0 2 0		PROG	RAM ID SAMPLE
0 0 1	0 3 0			
0 0 1	0 4 0		ENVI	RONMENT DIVISION
0 0 1	0 5 0		CONF	IGURATION SECTION
0 0 1	0 6 0		SOUR	CE COMPUTER IBM 360
0 0 1	0 7 0		OBJE	CT COMPUTER IBM-360
0 0 1	0 8 0			
0 0 1	0 9 0		INPU	T OUTPUT SECTION
0 0 1	1 0 0		FILE	CONTROL
0 0 1	1 1 0			SELECT MASTER-FILE ASSIGN
				TO SYS 001-UT 2400-S
0 0 1	1 2 0			SELECT DATA-FILE ASSIGN
				TO SYS 002-UT-2400 S
0 0 1	1 3 0			SELECT PRINT-FILE ASSIGN
				TO SYSIPT-OR-2501-S
0 0 1	1 4 0			
0 0 1	1 5 0		DATA	DIVISION
0 0 1	1 6 0		FILE	SECTION
0 0 1	1 7 0			
0 0 1	1 8 0		FD MA	STER FILE
0 0 1	1 9 0			BLOCK CONTAINS 10 RECORDS
				RECORD CONTAINS 40 CHARAC
				TERS

RAM-ACCOUNTS RECEIVABLE

ENCE				CONT	A	B	
) Serial							
3	4		6	7	8	12	
2	0	1	0			LABEL RECORDS ARE. OMITTED.	
2	0	2	0			RECORDING MODE I SF.	
2	0	3	0				
2	0	4	0		01 MAS	TER-REC.	
2	0	5	0			05 CUST-NO	PIC 9(5).
2	0	6	0			05 CUST-NAME	PIC X(35)
2	0	7	0				
2	0	8	0		FD	DATA-FILE	
2	0	9	0			BLOCK CONTAINS 10 RECORDS.	
2	1	0	0			RECORD CONTAINS 60 CHARAC-TERS.	
2	1	1	0			LABEL RECORDS ARE OMITTED	
2	1	2	0			RECORDS MODE IS F	
2	1	3	0				
2	1	4	0		01	DATA-REC.	
2	1	5	0			05 DOC-1D	PIC xx.
2	1	6	0			05 DOC-NO	PIC 9(6).
2	1	7	0			05 DOC-DATE	PIC 9(6)
2	1	8	0			05 ACCOUNT-NO	PIC 9(5).
2	1	9	0			05 FILLER	PIC X(20).
2	2	0	0			05 DR-CR	PIC 9.

PROGRAM ACCOUNTS RECEIVABLE

SEQUENCE (Page) Seqal						CONT	A	B	
1		3	4		6	7	8	12	
0	0	3	0	1	0			05 AMOUNT	PIC 9 (8)V 99
0	0	3	0	2	0			05 FILLER	PIC X(12)
0	0	3	0	3	0				
0	0	3	0	4	0		FO PRI	NT-FILE	
0	0	3	0	5	0			LABEL RECOROS ARE OMITTED	
0	0	3	0	6	0				
0	0	3	0	7	0		01 PRI	NT REC	PIC X(132)
0	0	3	0	8	0				
0	0	3	0	9	0		WORKIN	G STORAGE SECTION	
0	0	3	1	0	0		77 LIN	E-LIMIT	PIC 99
0	0	3	1	1	0		77 PAG	E-NO	PIC 999
0	0	3	1	2	0		77 OR	CTR	PIC 9(8)V99
0	0	3	1	3	0		77 CR	CTR	PIC 9(8)V99
0	0	3	1	4	0		77 FLA	G	PIC XX
0	0	3	1	5	0		77 PRE	VIOUS NO	PIC 9(5)
0	0	3	1	6	0				
0	0	3	1	7	0		01 HEA	O'NG LINE	
0	0	3	1	8	0			05 PARTY-NO	PIC 9(5).
0	0	3	1	9	0			05 FILTER PIC X(5) VALUE SPACES	
0	0	3	2	0	0			05 PARTY NAME	PIC X(35)

PROGRAM-ACCOUNTS RECEIVABLE

SEQUENCE (Page) Serial						CONT	A	B	
1		3	4		6	7	8	12	
0	0	4	0	1	0			05 FILLER	PIC X(10) VALUE SPACES.
0	0	4	0	2	0			05 PAGE-DES	PIC X(8) VALUE "PAGE-NO"
0	0	4	0	3	0			05 PAGE-SR	PIC ZZ9.
0	0	4	0	4	0			05 FILLER	PIC X(66) VALUE SPACES.
0	0	4	0	5	0				
0	0	4	0	6	0		01 DET	AIL-LINE	
0	0	4	0	7	0			05 VOUCHER-ID	PIC XX.
0	0	4	0	8	0			05 FILLER	PIC XXXX VALUE SPACES.
0	0	4	0	9	0			05 VOUCHER-NO	PIC Z(5)9.
0	0	4	1	0	0			05 FILLER	PIC xxxx VALUE SPACES.
0	0	4	1	1	0			05 VOUCHER-DATE	PIC 99B99B99.
0	0	4	1	2	0			05 FILLER	PIC X(10) VALUE SPACES.
0	0	4	1	3	0			05 DR-AMOUNT	PIC Z, ZZ, ZZZ, ZZ.
0	0	4	1	4	0			05 FILLER	PIC X(5) VALUE SPACES.
0	0	4	1	5	0			05 CR-AMOUNT	PIC Z, ZZ, ZZZ, ZZ.
0	0	4	1	6	0			05-FILLTER	PIX(71)
								05-FILLER	PI X(71) VALUE SPACES.
0	0	4	1	7	0				
0	0	4	1	8	0		01 TOT	AL-LINE.	
0	0	4	1	9	0			05 FILLER	PIC X(24) VALUE SPACES
0	0	4	2	0	0			05 TOTAL-DES	PIC X(8) VALUE "TOTAL*".

PROGRAM ACCOUNTS RECEIVABLE

SEQUENCE (Page) Serial 1–6	CONT 7	A 8	B 12
005010			05 OR TOTAL PIC ZZZ ZZ.
005020			05 FILLER PIC XXX ZZZ ZZ VALUE SPACES
005030			05 CR TOTAL PIC ZZZ ZZ
005040			05 FILLER PIC X(71) ZZZ ZZ VALUE SPACES
005050			
005060		PROCEO	URE OIVISION
005070		BEGIN	
000080			OPEN INPUT MASTER FILE data FILE OUTPUT PRINT FILE
005090			READ MASTER FILE AT ENO MOVE 99999 TO CUST NO
005100			READ OATA FILE AT ENO MOVE NO TO FLAG
005110			IF FLAG= NO DISPLAY NO OATA IN FILE JOO ABORTEO
005120			GO TO JOB ENO
005130		MORE O	ATA
005140			MOVE ACCOUNT—NO TO PREVI OUS—NO PARTY—NO
005150		COMPAR	E5
005160			IF CUST—NO ACCOUNT—NO THEN NEXT SENTENCE ELSE
005170			GO TO NEXT COMPARE
005180			READ MASTER—FILE AT ENO MOVE 99999 TO CUST—NO
005190			GO TO COMPARE
005200		NEXT	COMPARE

PROGRAM-ACCOUNTS RECEIVABLE

SEQUENCE (Page) Serial						CONT	A	B
1		3	4		6	7	8	12
0	0	6	0	1	0			IF CUST-NO ACCOUNT-NO MOVE SPACES TO PARTY-NAME.
0	0	6	0	2	0			CUST ELSE MOVE CUST-NAME TO PARTY-NAME.
0	0	6	0	3	0		FIRST	SEC.
0	0	6	0	4	0			PERFORM HEADING-RTN.
0	0	6	0	5	0		NEXT	SEC.
0	0	6	0	6	0			PERFORM DETAIL-RTN.
0	0	6	0	7	0			READ DATA—FILES AT END MOVE "NO" TO FLAG.
0	0	6	0	8	0			IF FLAG="NO" PERFORM TOTAL-RTN GO TO JOB-END.
0	0	6	0	9	0			IF PREVIOUS—NO NOT=ACCOUNT NO PERFORM TOTAL-RTN.
0	0	6	1	0	0			GO TO MORE-DATA.
0	0	6	1	1	0			IF LINE-LIMIT 55 GO TO FIRST-SEC.
0	0	6	1	2	0			GO TO NEXT-SEC.
0	0	6	1	3	0		JOB EN	D.
0	0	6	1	4	0			CLOSE MASTER-FILE DATA-FILE PRINT-FILE.
0	0	6	1	5	0			STOP RUN.
0	0	6	1	6	0		HEADIN	G-RTN.
0	0	6	1	7	0			ADD 1 TO PAGE-NO.
0	0	6	1	8	0			MOVE PAGE-NO TO PAGE-SR.
0	0	6	1	9	0			WRITE PRINT-REC FROM HEADING-LINE AFTER CHANNEL-1.
0	0	6	2	0	0			WRITE PRINT-REC FROM SPACES AFTER 2.

PROGRAM ACCOUNTS RECEIVABLE

SEQUENCE (Page) Serial 1 3 4 6	CONT 7	A 8	B 12
007010			MOVE 3 TO LINE LIMIT
007020		DETAIL	RTN
007030			MOVE DOC IO TO VOUCHER IO
007040			MOVE DOC NO TO VOUCHER NO
007050			MOVE OOC DATE TO VOUCHER OATE
007060			IF DR CR=1 MOVE AMOUNT TO OR AMOUNT MOVE ZEROS TO CR
007070			AMOUNT ADD AMOUNT TO DR CTR ELSE
007080			MOVE AMOUNT TO CR AMOUNT MOVE ZEROS TO DR AMOUNT ADO
007090			AMOUNT TO CR CTR
007100			WRITE PRINT REC FROM DETAIL LINE AFTER 1
007110			ADD 1 TO LINE LIMIT
007120		TOTAL	RTN
007130			WRITE PRINT REC FROM SPACES AFTER 1
007140			MOVE CR CTR TO CR TOTAL MOVE DR CTR TO OR TOTAL
007150			WRITE PRINT REC FROM TOTAL LING AFTER 2
007160			MOVE ZEROS TO OR CTR CR CTR
007170			
007180		* * *	* * * * END OF PROGRAM * * * *
007190			—
007200			

GLOSSARY

Absolute Value. An integer or a whole number represented by a symbol, as 0, 1, 2, 3, 4, 5, etc. A decimal number system has ten absolute values 0 to 9.

Access Time. The period of time between a request for the transfer of data to or from a storage device and the completion of this operation. For devices with mechanical movement (e.g., magnetic tape, disk or drum) it depends upon the speed with which the storage location is accessed and the time for transfer of data.

Accounting System. An Information System that is designed to support the handling of data and the decision-making needs of the accounting process and of the people who make decisions. An efficient Accounting System should, from the planning viewpoint, be flexible, that is, capable of providing multipurpose information quickly, and from the control viewpoint, it should give uniform and consistent standards of performance so that valid comparisons can be made.

Address. Place where information is stored.

Algol. ALGOrithmic Language. A data processing language used to express problem solving formulae for solution by machines.

Analog. Representation of numerical quantities by physical variables such as translation, rotation, voltage or resistance.

Analog Computer. This computer solves problems by translating physical conditions like temperature, speed, etc. into electrical quantities and uses electrical equivalent circuits as an analog for the physical phenomena being investigated.

Analysis. A human judgmental process, which may be computer based, that is used for evaluation or problem solving. (See Systems Analysis).

Arithmetic Unit. A major component of the Central Processing Unit (CPU) of a computer which performs all the arithmetic operations under the directions of the control unit.

Assembler. A computer program which makes it possible for a computer to operate upon a symbolic language program and produce a machine language program which can then be directly executed by the computer.

Base. There are various number systems, e.g., decimal, binary, octal and hexidecimal. Base is the value which indicates the number of absolute values used in the system, i.e., 10 for decimal, 2 for binary, 8 for octal and 16 for hexidecimal.

Batch Processing In EDP the collection of similar input data elements may be grouped together into a large data pool and processed in a single computer run (In real time processing the data elements are processed at the time they are collected)

Binary Digit (Bit) Binary number system has base 2 i e 2^0 2^1 2^2 2^3 etc and has two digits 0 and 1 Bit is an abbreviation and denotes a single character in a binary number

Block One or more records considered or transferred as a unit particularly with reference to input/output

Buffer An intermediary storage between two storage or data handling systems or between a data processing unit and a data transmission unit

Business Application Computer applications related to business e g invoicing inventory control scheduling payroll etc

Byte A group of binary units usually operated on as a unit A byte is equivalent to an 8 bit EBCDIC character

Card Punch A device for punching holes on cards to represent data

Card Reader This device reads or senses holes in cards and transforms the data (represented by the holes on the card) to patterns of electrical impulses Both the card punch and card reader have automatic devices for holding the cards and for feeding them one by one through the punching or sensing station and stacking the cards back

CBMIS Computer based Management Information System

Centralised Processing A central computer facility is connected to a system of data terminals which transmit data to the central computer The computer maintains and updates the data base and transmits the processed data and enquiries to the remote locations

Central Processing Unit (CPU) The major components of a CPU of a computer are the control unit the arithmetic/logic unit and the storage unit The CPU is the controlling centre of a digital computer system which processes data supervises and coordinates the various functional units of the computer system and provides primary storage capacity

Character A symbol of a set of elementary symbols For example 0 to 9 A to Z symbols like question mark asterisk flowchart symbols etc

Check Digit Data is verified by assigning an extra digit to coded numbers and this enables the computer to perform the arithmetic needed to establish the probable accuracy of the number

Classifying Grouping data into categories or classes

Cobol. Common Business Oriented Language. A programming language in data processing. It is designed to express data manipulation and processing problems in English narrative form in a precise and standard manner.

Coding. The most direct way for a programmer to communicate with the computer is to code his instructions in machine language—the language of the computer. Numerical codes or alpha-numerical codes (mnemonics) can be used.

Coding Check. A means for verifying data to conform that the coding is correct.

Colate. Merging of two or more ordered sets of data to produce one ordered set. In collation, two sequences are merged, each ordered on some mutual key, into a single sequence ordered on the mutual key.

Communications Control Unit (CCU). The central CPU communicates with the various input/output devices through the CCU. Data channels connect the CPU and CCU and these control the flow of information into and out of the computer.

Computer. It is an electronic device which is capable of solving complex problems by accepting data, performing prescribed operations on the data in terms of a specific program and supplying the results of these operations. The characteristics of an electronic digital stored program computer are:

1. It performs arithmetic operations and logical operations on a set of numerical (digital) data. Since it performs computations it is called a computer.
2. It is ordered to perform these operations by sequence of instructions or Program which is stored in the "memory" of the computer.
3. The operations are performed and the data and instructions stored by varying the electrical and magnetic configurations of a large aggregate of electronic circuits.

Computer Science. The broad spectrum of theoretical and applied disciplines associated with the development of the computer including contributions from mathematics, logic, computer design, language analysis, information systems, systems analysis, etc.

Computer Programme. An integrated set of instructions for a computer to use in performing a particular task.

Computer Justification. The process of evaluating the various factors including costs and benefits of acquiring a computer.

Computer Simulation. Simulation through the use of a computer of physical or real world systems or phenomena being investigated by converting them into mathematical or physical modes.

Console A computer operator communicates to a computer by means of a console It contains lights keys, switches and related circuits for man machine communication The console can be used to give various instructions e g enable the machine to be manually controlled correcting errors determine the status of machine circuits, determine the contents of storage or revise the contents of the storage and so on

Computing See computer

Cost Benefit Analysis An analytical approach to solving problems of choice between alternatives It requires the definition of an objective and evaluating the costs and benefits involved in the various alternatives to attain that objective The choice would be on that alternative that yields the desired benefits for the least cost

Core See magnetic core

Database A set of data internally accessible on which computer operations are performed An integrated set of files and records usually complete and self contained

Data Element A specific item of information appearing in a set of data For example unit of product unit rate value per unit are all data elements

Debugging Locating and correcting errors in a computer programme Also detecting and correcting malfunctions in the computer itself

Decision Criteria Identified conditions or actions that are necessary before a decision is taken

Decision Table A table showing possible courses of action or alternatives or contingencies to be considered in a specific problem with courses of action These tables are used in place of flow charts for describing problems analysis and accompanying documentation

Development Costs One time costs of systems development consisting of analysing and documenting the existing system designing the new system and programming debugging and implementing the new system

Digital Pertaining to discrete integral numbers in a specified base to represent all quantities that occur in a problem or a calculation

Digital Computer A computer which processes information represented by combinations of discrete or discontinuous data An analog computer utilises continuous data A digital computer is capable of performing sequences of arithmetical and logical operations based on internally stored instructions not only on data but also on its own programme

Direct Access Storage devices can have a direct access or a sequential access A magnetic tape is an example of sequential access

medium. That is, to locate a desired record, the tape must be searched from the beginning till the desired record is located. The storage locations on magnetic tapes are not addressable. In contrast, a direct access device is addressable and a particular record can be located without searching. Each record can be accessed (by its identifier), and operated upon without the need of sequential searching.

Diskette. A small magnetic disk almost resembling a 45 rpm record. It is sealed in a plastic packet about eight inches square. The diskette is reusable, can be easily corrected or updated and can be used to record nearly 2000 records upto 128 characters in length.

Documentation. Organisation and communication or recorded knowledge to maintain a complete record. A proper system of documentation greatly helps in minimising mistakes. Thiis will consist of system design, input/output specifications, processing rules, decision logic, file specifications, input/outpur formats, file layouts, file processing procedures, narratives, code, flowcharts, computer operations, data control, key entries, operations procedures, etc.

Display. Presentation of information such as by projection on a screen, an audio message, a computer print-out, etc.

Edit. To rearrange data or information by deletion of unwanted data, selection of pertinent data, application of format techniques, insertion of symbols such as page numbers or typewriter characters, etc.

EBCDIC. Extended binary coded decimal interchange code. In this system, data is represented by characters represented by a combination of eight-bit positions (excluding parity-bit positions). The eight positions consist of four zone bits and four numeric bits.

External Storage. A storage device outside the computer that can store information in a form acceptable to a computer. Examples are punched cards, magnetic tape, documents coded with magnetic ink characters, etc.

Field. An assigned area in a computer record for a particular element of data or item of information.

File. An organised collection of information directed towards some purpose. The records in a file may or may not be sequenced according to a key contained in each record.

File Maintenance. The activity of keeping a file by updating it, i.e., by adding, deleting or altering data contained in it.

Flowchart. A schematic or graphic presentation of the logic required to solve a problem.

Fortran. FORmula TRANslator A programming language designed for problems which can be expressed in algebraic notations. It was

originally conceived for use on scientific problems but is often now adapted for use in commercial problems also

Hardware Physical equipment composing the computer such as the mechenical electronic and magnetic units (see software)

Hash Total Totals of items contained in certain fields used for control of input processing and output operations

Hard Copy Punched copy of a machine output listings documents summaries etc as distinct from punched cards magnetic tape paper tape or other similar media

High Order Language Programming languages that do not have the limitations of a specific computer such as COBOL FORTRAN and PL/I

Hybrid Computer A combination of analog and digital computer

Implementation Costs One time costs in system development consisting of costs on training of personnel to operate the system plus the cost of installing and testing the system

Information System The network of communication methods within an organisation

Input Data transferred to the internal storage of a computer and meant for processing

Input Specification A document prepared by the Systems Analyst that describes the appropriate input content and media required for the system

Instruction A coded program step that informs the computer what to do

Integrated Data Processing A system that treats as a whole all data processing requirements of an organisation It achieves the reduction of data entry and processing steps

Keyboard Printer A device by means of which messages and data can be transmitted between a remote user and a computer

Key Disk System Data is entered from a keyboard device (similar to a typewriter) and recorded onto a magnetic disk

Key Punch Machine Machine for punching cards

Key Tape System Same as key disk except that data is recorded on magnetic tapes

Line Printer A printing device in which the entire line of characters is composed and determined within the device prior to printing

Location An addressable area in the main memory of a computer or its auxiliary storage where a unit of data may be stored or retrieved

Logical Operations Examination of data to determine relationships

such as comparing, selecting, referencing, matching, sorting, merging, etc.

Low Order Language. Programming languages that closely resemble machine language (see definition below).

Machine Language. Programming language or instruction code used directly by the computer. The code (binary based notation) is in a form directly acceptable to a computer and requires no translation.

Magnetic Core. The internal storage unit in a computer consists of magnetic cores. A core is a tiny element about the size of a grain of salt. It is moulded from magnetic material like nickel-zinc ferrite. The important property of a core is its ability to be polarised in two directions—clockwise or anti-clockwise, said to be ON or OFF respectively. As such, it can represent the binary digits 0 and 1.

Magnetic Disk. A storage device on which information is magnetically recorded on a rotating surface. Data is arranged in circular tracks around the disks and are accessible to reading and writing heads, mounted on a movable arm. This arm can be moved mechanically to the desired disk and then to the desired track on that disk. Data from a given track is read or written sequentially as the disk rotates.

Magnetic Drum. A rapidly rotating cylinder on which binary information is stored. Data is written and sensed by a set of read-write heads positioned close to the surface of the drum, while it is rotating at high speed.

Magnetic Tape. An external storage medium in the form of metallic or plastic tape on which bits may be recorded magnetically as a means of retaining data.

Management Information System (MIS). An Information System in which data is recorded and processed to help decision making by senior management and where information is fed back to them to reflect the state of progress in achieving objectives.

Master File. A set of relatively permanent records containing identifying, statistical and historical information usually used as a source of information for a specific application.

Memory. A device in which data can be stored and retrieved later. The means of storing may be chemical, mechanical or electrical. This is also known as storage.

Merging. Combining two or more files into a single file in the same sequence.

Microsecond. One millionth of a second.

Millisecond One thousandth of a second

Minicomputer Usually weighs less than 25 Kg and contains a relatively small memory It can accept peripherals such as a disk storage magnetic tape units and line printers

Mode A computer system of data representation e g , a binary mode

Module A separate and distinct part of a system though very much an integral part of it that can be compiled independently

Nanosecond One billionth of a second

Off Line Describes the peripheral equipment not under the control of the central processing unit

On Line A system and its peripheral equipment whose operation is under the control of the CPU

Operating Costs Recurring costs in operating a system

Output Information transferred from a computer to a device outside the computer

Output Specifications These identify precisely what the system should provide to the user In Systems Analysis this is the starting point of a system development project

PL/I A general purpose data processing language It combines the features of FORTRAN and COBOL However it is relatively complex and therefore not very popular

Payback (Payoff) Period Period of time required for the total net cash receipts produced by an investment to equal the original cash outlay

Peripherals Input output and secondary storage devices that represent the means by which data is input stored retrieved and output from the computer

Peripheral Storage See secondary storage

Primary Storage Storage that is considered an integral part of the CPU It contains the computer programs and the data to be processed by the programs (See secondary storage)

Program A set of instructions or steps that directs the computer and coordinates the operations of its various components

Punched Card A paper card that is punched with a pattern of holes that represent information It is an input output media for digital computers The punched holes are sensed electrically by wire brushes mechanically by metal feelers or photo electrically

Punched Paper Tape Paper tape on which holes are cut to represent data

Random Access See Direct access

Record Set of data pertaining to a particular item Typical records are inventory records personnel records and sales records

Recording Density. The number of characters of symbols recorded or stored in a unit of length, area or volume of a storage device.

Return on Investment Analysis. An analysis to determine the return that may be expected from the investment made. ROI is a good management tool to choose from various investment alternatives.

Secondary Storage. Supplement to primary storage. Devices include magnetic disk units, magnetic drums and magnetic tape.

Sequential Access. See Direct access.

Sequential File. A file in which the records are arranged in sequence in accordance with a code. To reach the record it is necessary to search for the record in sequence till the desired record is located.

Software. Procedures, instructions, code sets, assemblers, compilers and all other associated supporting processes required to run a computer programme on the equipment itself.

Sorting. The arranging of a list (or file) of data in a desired sequence.

Sub-System. One of a number of component parts of a system. All the sub-systems must function together in an integrated manner for the system to operate as designed.

System. An organised collection of parts, elements, objects or events united by regulated inter-action and designed or required to accomplish a specific purpose or objective. Collective organisation of information, these possess and the means for acquiring, storing, transmitting, controlling or otherwise processing such information.

Systems Analysis. Study and analysis of a system with a view to designing a new system, improving the existing system or solving a system problem.

Systems Analyst. An individual who analyses a system by the use of scientific techniques in order to determine where and how improvements can be made with a view to meet objectives in a more efficient, effective and economical manner.

System Feasibility Study. The evaluation of advantages and benefits compared to costs involved in converting a manual system into a computer based system.

Systems Tests. Testing of each component (module) of a computer system by using actual past data or hypothetical data and analysing the results in order to ensure that the system is trouble free. System tests are made with the object of testing the accuracy, capability and adequacy of an entire system.

Terminal. The point at which data can enter or leave a communication network.

Time-Sharing System. An on-line system in which many users share availability of a remote central computer.

Total Systems Concept An integral approach to the design, development, operational decision making problem solving or information systems in general The various sub systems are integrated during the design phase with the overall, single, cohesive framework Quite often the entire enterprise or organisation with its various constituent parts is conceived of as a single system entity

Variable Data element whose numerical value alters from one repetition of a programme to the next For example the cost of a product may be constant but the volume will be variable

Video Display A device by which on line data is visually displayed on a screen like a TV screen Display units are widely used where it is necessary to provide direct access to computer files

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